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VOLUME VI
Numbers 25 to 30
1914

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PROFESSIONAL MEMOIRS

Corps of Engineers, United States Army, and Engineer Department at Large

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Contents

(*Illustrations in each article are shown by italics.*)

Page.

1. THE PORT OF NEW ORLEANS 1-47
By Capt. C. O. Sherrill, Corps of Engineers.
New Orleans and Vicinity 3
South Pass Bar 8
Profile of Bar at mouth of Southwest Pass 14
Southwest Pass 16
Tug towing loaded barges 17
Constructing mats on ways 19
Launching completed mats 20
Tracks on to jetty 21
Construction in situ of inner mats 23
Inner mats, complete with ballast 24
Mattress, partly ballasted and ready to sink 25
Completed inner jetty 27
Towing mats to site of sinking 28
Standard submerged sloping spur dike for bank revetment 29
Piling, showing method of aligning mats 31
Mixing and filling plant 32
Forms for concrete monoliths 33
Completed concrete superstructure from sea side 35
Completed jetty, showing break in concrete superstructure 36
Banana unloader 39
Derrick barge wrecked during storm 45

2. AN OPEN LETTER ON NIGHT FIGHTING AND OUTPOSTS 48-68
Rough sketch of country north of Ladysmith 51
Sketches 53, 55, 59

3. THE COLBERT SHOALS CANAL, TENNESSEE RIVER, ALABAMA. 69-101
By Maj. H. Burgess, Corps of Engineers; M. Am. Soc. C. E
Lock and artificial mound 73
Lock and artificial mound at lower end of Colbert Shoals Canal 75
Bear-trap drift sluice 79
Cross section of weir No. 1 81

4. TESTS OF THE BANGALORE TORPEDO 102-110
By Capt. F. B. Wilby, Corps of Engineers.
The Bangalore Torpedo 103
Bangalore torpedo, showing interchangeable sections complete 105
Lengthwise view of entanglement 106
Preparations for and results of tests 107-110

5 CONCRETE IN SEA WATER ON NEW ENGLAND COAST 111-118
By Col. Frederic V. Abbot, Corps of Engineers; M. Am. Soc. C. E.

6. CONCRETE WHERE EXPOSED TO SEA WATER OR FROST 119-123
By Lieut. Col. W. E. Craighill, Corps of Engineers.
Concrete toe with round stones on foreshore 114
Concrete toe where pitted 116

7. CONCRETE LAID IN FREEZING WEATHER, N. Y. BARGE CANAL. 124-127
By Mr. D. A. Watt, Assistant Engineer; M. Am. Soc. C. E.

8. DISCUSSION ON CONCRETE 128-130
By Col. W. M. Black, Col. F. V. Abbot, and Col. John Millis, Corps of Engineers; Members American Society Civil Engineers.

9. THE BATTLE-SIGHT 131-132
By Maj. Amos A. Fries, Corps of Engineers; M. Am. Soc. C. E.

10. LIEUTENANT-COLONEL GAILLARD (see frontispiece) 133-134

11. BOOK REVIEW 135

12. TABLE OF ENGINEER DISTRICTS 136

13. EDITORIAL NOTES 137-138
Prizes for Articles for 1914 137
Number 2, Volume I 137
Award of Prizes 137-138

14. SELECTED ARTICLES OF ENGINEERING INTEREST .... viii-xix
Compiled by Mr. Henry E. Haferkorn, Librarian, Engineer School.

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LIEUT. COL. DAVID DU BOSE GAILLARD

HARRIS & EWING

CORPS OF ENGINEERS, UNITED STATES ARMY

BORN 1859—DIED 1913

SEE PAGE 133

The Port of New Orleans

BY

Capt. C. O. SHERRILL
Corps of Engineers

New Orleans is the largest city on the Gulf Coast and second seaboard city of the United States in the tonnage of its in-coming and out-going commerce. It is situated on the east bank of the Mississippi River about 95 miles from the head of the Passes, and 110 miles from the Gulf through South Pass Channel (see Fig. 1). In view of the intimate relation between the channel from the city to the Gulf and the harbor proper, the term ''Port of New Orleans'' is taken to include both. Inasmuch as its location is at the mouth of the largest river system in the country, and as it is the terminus of a large number of railway lines, it naturally has developed rapidly in importance and has considerable advantages both as a seaport and as a river port.

The Mississippi River, with its more than fifty tributaries, having a total length of 13,000 miles, provides the most extensive system of navigable waters in the world as feeders to the commerce of the Port of New Orleans, which must eventually be the great transfer depot of the Gulf Coast, from river barge to ocean steamer, if the inland rivers ever become commerce carriers in accordance with their possibilities.

The navigable streams in the Mississippi system spread out fan-shaped to the Appalachians on the east, the Rockies on the west and the Canadian border on the north, draining ten states with an area of 1,256,000 square miles, or about 41 per cent of the territory of the United States. New Orleans is also connected with the east and west by a number of lateral canals, of which may be mentioned Harveys Canal (lock width, 30 feet; depth, 6 feet); Companys Canal (lock width, 25 feet; depth, 6 feet); Bayou Plaquemine through the Plaquemine lock on the west (lock width, 55 feet; depth, 10 feet); Lake Borgne Canal (lock width, 40 feet; depth, 7 feet); New Basin (width, 100 feet; depth, 8 feet), and Carondelet

Canal (width, 55 feet; depth, 7 feet) on the east; besides several others of less importance from the east and west. The Carondelet and New Basin canals are used largely for industrial purposes and accommodate a large fleet of luggers and material barges. They furnish channels from the heart of the city out into Lake Pontchartrain, thence through the Rigolets and Chef Menteur Passes into Lake Borgne, and finally into Mississippi Sound and the Gulf of Mexico. At the present time the Lake Borgne Canal is being improved by its owners with a view to extensive use in carrying coal from Alabama fields to New Orleans by way of the Black Warrior and Tombigbee rivers, when their canalization is completed. When this all-water route is available, Alabama coal can be brought to New Orleans at a much lower figure than at present and it will be a formidable rival of Pittsburg coal by way of the Mississippi River. The Lake Borgne Canal owners have recently launched one 1,000-ton self-propelled steel barge for the Alabama coal trade, and have several others under construction. These barges are 240 feet long and 32 feet beam by 6 feet draft, with a speed of 8 miles per hour, and requiring a crew of seven men. They have two 75-horsepower internal combustion engines. The canals in the vicinity of New Orleans give ample water routes to the coast territory of Louisiana, Texas, Mississippi and to the coal fields of Alabama.

The early history of New Orleans is interwoven with that of its French settlers, and even to-day the French language is often heard in its theaters and streets, and many of its citizens are of French descent. The city, as capital of the Western Company, was laid out in 1718 under the French colonizer Bienville, by an engineer named Delatour, who provided for a levee over a mile long to protect the town from floods on the Mississippi River. The French in 1763 ceded to Spain all that portion of Louisiana west of the Mississippi River, including the island on which New Orleans was situated until the closure of the Iberville Bayou. New Orleans again came under the French control by the treaty of St. Ildefonso in 1800, but the actual transfer was not made. The Louisiana Purchase was made by President Jefferson in 1803, the controlling reason of which was to relieve American inland commerce of the burden of passing through foreign territory to reach the Gulf. This American commerce in 1802 consisted of 158 American vessels sailing out of the Mississippi River.

The site selected for the city of New Orleans was chosen not on account of its superior advantages of topography, because the origi-

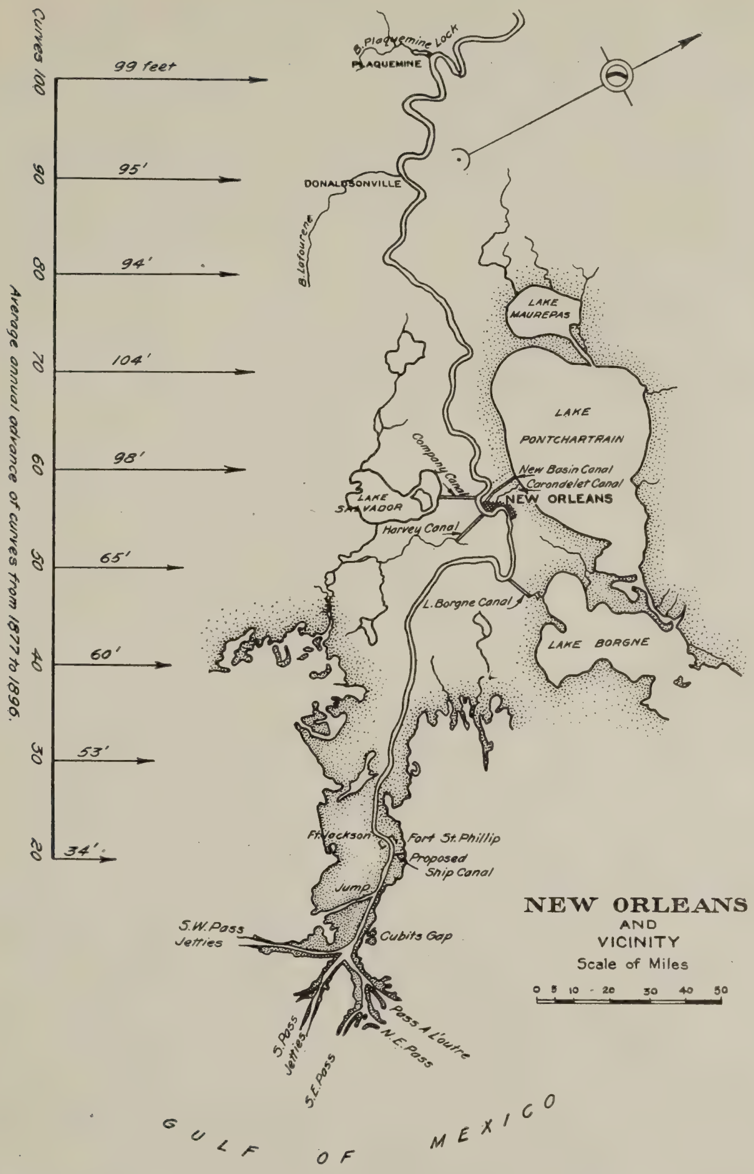
Curves 100
90
80
70
60
50
40
30
20
99 feet
95'
94'
104'
98'
65'
60'
53'
34'
Average annual advance of curves from 1877 to 1896.
B. Plaquemine Lock
PLAQUEMINE
DONALDSONVILLE
B. Lafourche
LAKE MAUREPAS
LAKE PONTCHARTRAIN
New Basin Canal
Carondelet Canal
NEW ORLEANS
Company Canal
LAKE SALVADOR
Harvey Canal
L. Borgne Canal
LAKE BORGNE
Ft. Jackson
Fort St. Phillip
Proposed Ship Canal
Jump
S.W. Pass Jetties
Cubits Gap
S. Pass Jetties
S.E. Pass
N.E. Pass
Pass A L'outre
NEW ORLEANS
AND
VICINITY
Scale of Miles
0 5 10 20 30 40 50
GULF OF MEXICO

Fig. 1. Arrows on scale at left show average annual advance into the Gulf of Mexico of bar and other depth contours at South Pass, Mississippi River, between 1877 and 1896.

nal condition of the locality was low, swampy and malarial, and New Orleans might as well have been located 50 or 75 miles nearer the Gulf, or preferably on the heights around Baton Rouge. Its site was determined by the location of a small stream called Bayou St. John, extending from Lake Pontchartrain nearly to the Mississippi River; and the colony at Biloxi, Miss., in their intercourse with the colony at Point Coupee, La., about 200 miles up the Mississippi, found Bayou St. John the most convenient place to portage their goods across to the river from Lake Pontchartrain, which had direct water connection with Biloxi by way of Lake Borgne and Mississippi Sound. In locating the city, its founders had the good fortune to accidently pick out a portion of the river where there are ample depths of water for the requirements of the modern large commerce, and where channel conditions have been very stable.

In the early days, all intercourse with the interior was carried on by the river route and New Orleans grew rapidly, notwithstanding its unhealthy location; but under modern conditions of drainage, water supply and sewerage, the city has eliminated the plagues of yellow fever and malaria which hampered its development until recent years, so that now it has become a pleasant place of residence throughout the year.

Previous to the Civil War New Orleans was the southern center of industry and culture, being the only Gulf port of any importance, but recent growth of rival ports, with the increase of railroad facilities at these points, such as Mobile, Pensacola, and Galveston, has retarded its relative growth with respect to other Gulf ports.

The first important step in the development of the city as a modern port was taken by the Government in opening up South Pass to vessels of 26-foot draft. This work was begun in 1875 and the Jetties were completed in 1879, since which date it has generally provided a channel 26 feet deep.

In 1902, Congress authorized the dredging of a channel 35 feet deep through Southwest Pass and the construction of jetties to maintain this channel. In view of the dependence of New Orleans port facilities on the channel to the Gulf, the development of the Passes is considered as an essential feature of the port.

One of the most difficult of the many problems met in the improvement of the Mississippi has been that of securing and maintaining adequate channels from the river to the Gulf. This problem is found in connection with every river carrying solid matter in suspension and flowing into almost tideless seas, such as the Gulf of Mexico. In its natural condition, the Mississippi above the Passes as far as New Orleans has always had sufficient depths and widths at all points for the needs of commerce. The river in this section varies in depth from 30 to 250 feet and averages in width about 2,500 feet. Twenty miles below Fort St. Philip it becomes 7,000 to 8,000 feet wide, with a maximum depth of 40 feet. Its erosive and transporting power maintain its channel without great lateral changes. The caving of the bends is slow as compared with that found on the upper river and usually averages less than 5 feet per year through any bend. In fact, one of the most striking characteristics of the river is its persistence in remaining in the channel which it scours out for itself, notwithstanding the friable character of its banks. The only apparent exception is in the frequent ''cut-offs'' made on the upper river in the past, and these have been caused by caving of the bends above and below a narrow neck until the bank is practically destroyed and the ''cut-off'' occurs. There is no evidence to show that the river has ever shifted its channel from its longer main outlets to the Gulf through a shorter one, where the total fall between the river and the Gulf is passed over in a small fraction of the distance required by the main channel. A case in point is the present outlet through Old River and the Atchafalaya, where the distance to the Gulf by the Atchafalaya route is less than one-half that by the main river. It would seem inevitable that the main river should eventually follow the shorter route, but this has not occurred.

The delta proper of the river begins at Old River, 300 miles above the Passes, where the first outlet to the Gulf occurs. Formerly there were a number of such outlets between this point and the Gulf, notably Bayou Plaquemine, at Plaquemine, La., and Bayou Lafourche at Donaldsonville, La. The former was closed by the extension of the Mississippi River levee line across its head in 1867, and the latter similarly closed in 1904. By reference to Fig. 1 herewith (see page 3) the locations of the outlets below New Orleans may be seen: the Jump (crevasse of 1839) and Cubitts Gap (crevasse of 1862), the former 85 miles and the latter 92 miles below the city. Each of these outlets branches into a number of subordinate passes opening to the Gulf in deltas of their own formation. Cubitts Gap is said to have originated in a small opening made as a short cut for fishing boats to the eastward. It, however, speedily enlarged to such an extent that by 1898 it had a width of

3,240 feet and a maximum depth of 72 feet, and carried 155,600 cubic feet of water per second, or nearly half as much as was carried at that time by Southwest Pass. In the same way the crevasse in the right bank of Pass A'loutre, which dates from 1891, was only 15 feet wide and 14 feet deep when discovered, but it grew rapidly in size until it now carries about 38 per cent of the water entering Pass A'loutre. Below Cubitts Gap there are no other outlets until the Head of the Passes is reached. These passes are in order from north through the east: Pass A'loutre (discharging more than 50 per cent of the volume going out through the Passes), South Pass (in the axis of the main channel, discharging 9 per cent of the whole), Southwest Pass (largest and most important of all, discharging about 41 per cent of the total). There are several passes branching from Pass A'loutre, namely, North Pass, Northeast Pass and Southeast Pass. Near the head of the main part of Pass A'loutre is the crevasse mentioned above. On account of the adverse influence of this crevasse on the improvement of South Pass in diverting some of its normal discharge, a number of unsuccessful attempts to close it have been made.

The channels in the South and Southwest Passes proper had depths, previous to any improvement work, from 27 feet to 83 feet. Across the bars of both passes the depth at mean low Gulf level was about 9 feet with 13 feet across the head of South Pass.

The first plans to improve the Passes by jetties were made by an engineer named Panger, early in the eighteenth century, but nothing was done until the nineteenth century. Originally, Southeast Pass was used for navigation, but this was later deserted and the others were all tried at various times. The first step toward artificial deepening of the Passes was by means of harrows to stir up the bottom. This gave a slight increase of depth. The next attempt was to combine jetties with the stirring process, which resulted in failure to improve conditions due to excessive frailness and too short length of the jetties. In the meantime, commerce was rapidly increasing and various boards were appointed to find some solution of the problem at a cost small enough to be justified by the conditions at that time. The plan for jetties which has been generally credited to Mr. Eads was recommended repeatedly, but Congress would not appropriate the necessary funds. Mr. Eads was a successful promoter and secured funds where others had failed.

In 1837, an appropriation was made for the improvement of the mouth of the Mississippi River and on recommendation of the Board of Engineers an attempt was made to open Southwest Pass by use of a bucket drag. The work accomplished was obliterated by a single storm and nothing further was done until 1852, when $75,000 was appropriated to open a ship channel by contract. On the recommendation of a mixed Army and Navy Board, a contract was let to the Towboat Association for a channel 18 feet deep and 300 feet wide by harrowing and dragging; the Board also recommended that in case of failure of this method, jetties should be built to confine the water. The harrowing was successful in maintaining the required depth for a year, but no further appropriations being made the channel had disappeared by 1856.

In 1856, another Board of Engineers recommended that a contract be let to the Towboat Association to keep open Southwest Pass by stirring and that jetties and closure of lateral passes be tried in Pass A'loutre, but the Secretary of War decided to try the jetties system at both passes. A contract was let and a mile of jetty on the east side of Southwest Pass was built, but being of too frail construction, it was destroyed by storms. The contractors were then allowed to resort to the stirring method, by which an 18-foot channel was maintained as long as the work was continued.

In 1867 to 1870, a powerful dredge was built for the work of stirring up the bottom and deflecting the material into the current, but only a slightly deeper channel than 18 feet resulted from this work.

In 1871, a survey was made by Captain Howell, Corps of Engineers, U. S. Army, and a Board of Engineer Officers reported on his project that a canal was feasible near Fort St. Philip with a depth of 27 feet, bottom width of 200 feet, at a cost of $10,273,000. This provided for a lock at the river end with a chamber 500 feet in length, 60 feet wide and 25 feet deep over the sill (see Fig. 1, page 3). General Barnard filed a minority report, claiming that the experience gained with dredges justified a further trial, but that the success of jetties at the Sulina mouth of the Danube presaged even greater success for use at South Pass. General Humphreys criticised the Barnard plan for jetties on the ground that the rapid advance of the bar made the extensions of the jetties expensive and uncertain. Col. John Newton, in a review of General Barnard's plan, strongly opposed it for the same reason. Here was the issue joined between the jetty advocates and its opponents, which has been carried over to the present day as to jetties proper, but more especially as to the extension of the principle to the use of levees along the Mississippi River.

The opponents of the jetty theory held that the bar would be extended into the Gulf at an enormously increased rate over the previous average for all the passes of 268 feet per year if the jetties were built; some estimates being as high as 1,014 feet per year at Southwest Pass and 2,240 feet at South Pass, the greater estimate for South Pass being due to the greater contraction of the channel between the jetty heads. The most plausible theory of the Mississippi Bar formation yet advanced is that stated in Humphreys and Abbott's report, published in 1858. This theory, in general outline, is that the fresh water, as it meets the salt water of the Gulf, rises on the latter at an angle depending mainly on the velocity of the river current. The material previously carried along the bottom by the river water is now dropped, forming the bar in the comparatively still salt water below the upper layer of fresh water flowing outward. The result is modified by wave and tide action in the Gulf and by the various stages of the river. Thus, at high water the increased velocity scours out the inner side of the bar and rolls the eroded material over the crest, building up the bar further out, more or less like the sand waves produced at all points of the river

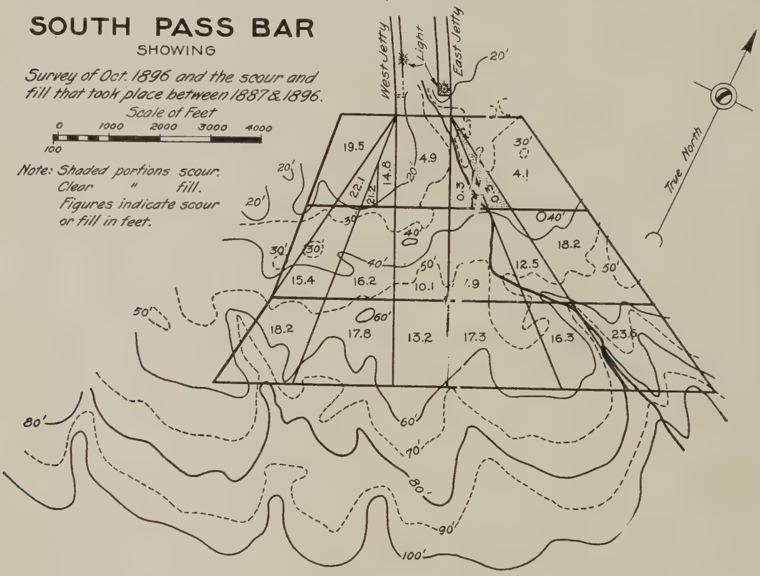
SOUTH PASS BAR
SHOWING
Survey of Oct. 1896 and the scour and fill that took place between 1887 & 1896.
Scale of Feet
0
1000
2000
3000
4000
100
Note: Shaded portions scour.
Clear " fill.
Figures indicate scour or fill in feet.
West Jetty
Light
East Jetty
True North
20'
30'
40'
50'
60'
70'
80'
90'
100'
19.5
22.1
21.2
14.8
4.9
0.3
4.1
18.2
12.5
15.4
16.2
10.1
7.9
17.8
13.2
17.3
16.3
23.6

Fig. 2.

in flood stage. When the river is low, its current is less and it deposits on the river side of the bar. Under this theory, the wider the area over which the water spreads a *given discharge*, the more slowly the bar advances into the Gulf and the higher the bar becomes, until a condition of equilibrium is reached when the extension of the outer crest equals the erosion of the inner crest; thereafter the depth, width, and rate of travel will be practically constant.

Careful observations between 1837 and 1857 on Southwest Pass Bar showed that the distance between the inner and outer 18-foot contours was practically constant at 7,500 feet and that the mean depth on the bar was unchanged. These surveys showed that the outer crest of the Southwest Pass Bar had advanced into the Gulf 338 feet a year over a width of 11,500 feet. Since the river was cutting out an area 1,200 feet wide and 338 feet long on the inner side of the bar to the mean depth of the pass, at the same time it was making a deposit 11,500 feet wide and 338 feet long on the outer side of the bar to at least the same depth; the difference between the erosion and the deposit, or about 10,000,000 cubic yards, is the amount of silt carried out through this pass per year. The quantity of matter transported through each pass is proportional to its discharge, so that the total amount of material discharged through the passes would be about 30,000,000 cubic yards. The mean depth bears, also, a rough direct proportion to the volumes of discharge, being greater in the larger passes.

From the dimensions of the bar and its rate of advance, Humphreys and Abbott calculated that it would take 55 years to form the bar as it then existed, assuming direct discharge through the pass into the Gulf without any intervening bar at the start. These various principles of bar formation led to many conclusions as to the results to be expected if the spread of the outflow should be prevented by jetties carried out to deep water beyond the bar. One school, led by Gen. Barnard, claimed that if jetties were extended to the required depth beyond the bar and the channel deepened by dredging, the force of the current would be sufficient to project the material far into the deep water of the Gulf, and thus the channel would be maintained until the conditions as to fill and distribution of material in the Gulf existing previous to the work should be reproduced. He laid great stress on the results produced at the Sulina mouth of the Danube by jetties. General Humphreys led the opposition and based his views on the theory that jetties in silt-bearing streams discharging into practically tideless seas would be a failure, as this was the case at the mouth of the Rhône, because there the bar is formed on the Humphreys-Abbott theory above mentioned, or else be very expensive to maintain, due to rapid seaward extension of the bar; but where the bar is formed at the mouth of fairly clear streams as result of littoral drift (sand and other loose material carried along the shore by wave and wind action), jetties would be advantageous. He also cites the Sulina Pass and the various harbors formed by jetties and dredging on the shores of the Great Lakes. It is undoubtedly true that General Humphreys' view was largely correct as to the method by which the greater part of the bars of the Mississippi passes are formed. Also, as to the ineffectiveness of jetties alone to open a channel of required depth, as claimed by General Barnard. His only error was in the rate he assumed that the bar would advance, namely, over 1,200 feet a year previous to the restoration of original conditions. In reality, this rate of advance was about 48 feet a year for 20 years, 1877 to 1897, for curves of 20 to 50 feet depth. His best example of greatly increased rate of travel of bars seaward was at the mouth of the Rhône, where jetties had deepened the channel to the required amount, but caused the bar to advance seaward three times as fast as previously with the old shallow channel depth across it.

Notwithstanding General Barnard's opinion that the maintenance of the channel would probably be cheaper with dredges, he was favorable to the jetty plan on theoretical considerations if Congress would only give sufficient money. On February 25, 1860, he wrote as follows: ''A word upon the plan of deepening the channels by the construction of jetties on the bars, which Mr. Ellet states is in violation of the law controlling the formation of bars. The experiments made by me demonstrate that this plan is based upon correct principles, and is in accordance with the laws under which the bars are formed. The plan of jetties has not been tried at the mouth of the Mississippi to a sufficient extent to show whether it would be effectual or not, for the contractor merely built one insecure jetty of a single row of pile planks, about a mile long, on one side of the channel, whereas the Board of 1852 recommended two jetties, each 14½ feet wide, composed of piles 2 feet apart, one on each side of the channel, each 5 miles long, if stirring up the bottom and dredging should fail. It is probable, however, that the plan of stirring up the bottom is the more economical of the two.''

On Fig. 1 is shown the advance of the curves of 20 to 100 feet depth into the Gulf from 1877 to 1896, indicating a most rapid advance for the curves of 60 and 70 foot depths. This is a clear demonstration of the errors into which the most learned may fall in making predictions based on theories of the probable changes liable to occur in a set of present physical conditions. The facts observed in the case of the effect of the South Pass jetties on the bar show that both schools of opinion were decidedly in error. The impossibility of maintaining the required depths without excessive dredging shows the folly of the theory that jetties alone would secure and maintain the channel; but on the contrary, the small average rate of advance of the bar per year subsequent to the construction of the jetties shows how far afield were the predictions that there would be a large increase in the rate of advance per year. There is one thing to be said for this latter view, and that is that there is a strong possibility that the rate of advance will increase much more rapidly after the restoration of what may be called the normal condition of the Gulf bottom depths outside the bar; this condition, however, will require probably 30 or 40 years more to be established, and can be met by extensions of the jetties.

It will be noted on Fig. 2 that the advance of the bar is generally fan-shaped, as would be expected, but this is much modified, showing a decided tendency of the deposits to move west near the jetties and of the channel across the bar to veer off to the east for a distance of 1,000 to 1,500 feet outside of the jetties along the line of the greatest depths. From this point, the deepest channel bends sharply to the east and extends thus seaward beyond the 100-foot contour, eight thousand feet from the jetties. Moreover, since the axis of south pass extends somewhat to the east of the direction of the prevailing storms, which are from the southeast, the tendency is to pile the deposit up on the west side of the channel, as shown in Fig. 2. This piling up of material on the west side tends to move the channel eastward. Fig. 2 also shows the extent of deposit and scour on the bar in 19 years.

Not only is the distribution of deposited material on the bar largely governed by the river current, but the effect of the Gulf Stream is less here than on the Gulf Coast to the east and west. The great storm of September 20, 1909, flooded the coast from Mobile to Galveston to a depth as great as 15 feet in some places, whereas at Port Eads, at the mouth of South Pass, the stage was but one and six-tenths feet above the mean. It is currently believed that the Gulf storms affect the height of the water in the river, but this is not true, the only effect being due to wind action on stretches of the river in piling up the water. The reason for the slight effect of Gulf storms at the passes is that the storms which raise the general Gulf level along the shoal beaches do not affect portions where there is considerable depth. The passes act like a pier extending into deep water, with the result that the deep currents counterbalance any effect of the storm in raising the height of the Gulf level.

Along the continental shelf the water is shallow, and is easily piled up by storms to great heights. The storms having the greatest effect in raising the Gulf level are from the northeast, east, and southeast. This arises from the fact that the Gulf stream flows up through the Straits of Yucatan, thence around the Gulf shore and out through Florida Straits. The easterly storms blowing here check the outflow and pile up the waters in the Gulf. It is also believed by some hydrographers that there is a Labrador current from the Florida straits west along the shore inland from the eastbound Gulf stream; this is supported by the fact that in winter there is a strong westward current off the passes, which, however, I believe to be more in the nature of an eddy current. It has often been contended that it is this westbound inshore current that carries the littoral drift along the shore, but I am rather inclined to believe that the storm waves have the greater effect in sand movement due to their greater violence, and especially since the normal Gulf currents on the coast are to the east in summer and to the west in winter and hardly swift enough to stir up and carry large amounts of heavy drift. Besides the main channel to deep water over the bar there are others similar in character but less in depth, two on the east and two on the west of the axis of the jetties. The axis of nearly all of these lies approximately in the direction of the prevailing storms, the waves from which deflect the deposit to one side or the other of the channels. This deflection of the main deep water channel to the east near the end of the jetties will give rise to a serious problem when the question of enlargement of the jetties comes up again, inasmuch as the extension of the present jetty would make it difficult to secure a sufficient base for the east jetty.

In 1912 and 1913, however, there appeared to have been notable changes of condition both on the bars and in the Passes. No survey has been made of the bar for ten years, but it is known that the channel was materially deepened by the exceptionally high river of 1912 to a minimum of 33 feet, and by the two high floods of 1913 to a minimum of 36 feet. The axis of the channel over the bar has also been found to be shifted almost into the prolongation of the jetties, removing the bend to the east shown on Fig. 2. River pilots say that they have never known such a swift current in the Passes and in the river generally as on the crest of the April, 1913, flood. It is a plausible explanation of the changed conditions this year to assume that the unusual floods in the river coming simultaneously with an exceptionally low Gulf have caused the river effect to predominate over that of the Gulf and extend the channel much further before it is affected by the cross-current.

Another notable feature of the South Pass improvement since the lateral openings were closed and the jetties built is that there has been a constant tendency for the channel depths throughout the pass to become much more uniform. Near the head of the pass and over the bar the scour has been extensive, while throughout the pass itself there is extensive shoaling in the parts formerly deepest, giving an average depth of about 30 to 40 feet. This is an important fact, leading to the belief that levees improve the *average* condition of a channel, filling in excessive depths and scouring abnormal shoals. This, of course, would only hold true where the levees follow closely the low water channel of the river, as is the case below New Orleans, and where the stream bottom is of soft material. At localities where there is no relation between the required channel capacity and the sectional area of high water flow between levee lines, as is found above Bayou Sara, La., on the Mississippi, there does not appear to be the slightest effect produced on the channel by levees, for they have no influence in holding the current over the low water thalweg.

An injurious effect of the extension of levee lines on the channel is that by restricting the flow to a small sectional area, higher flood heights are caused and more extensive caving of the banks occur. This has been observed recently at the head of the Passes, where extensive caving is occurring with danger of permanent injury to the improvement works. Since the three high floods of 1912 and 1913 the bank caving is probably greater than ever before observed. Where local conditions as near New Orleans admit of it waste weir outlets would reduce flood heights and be of resultant great advantage without damaging the channel, due to deposits of silt, as is claimed to be the result of natural outlets, since the waste

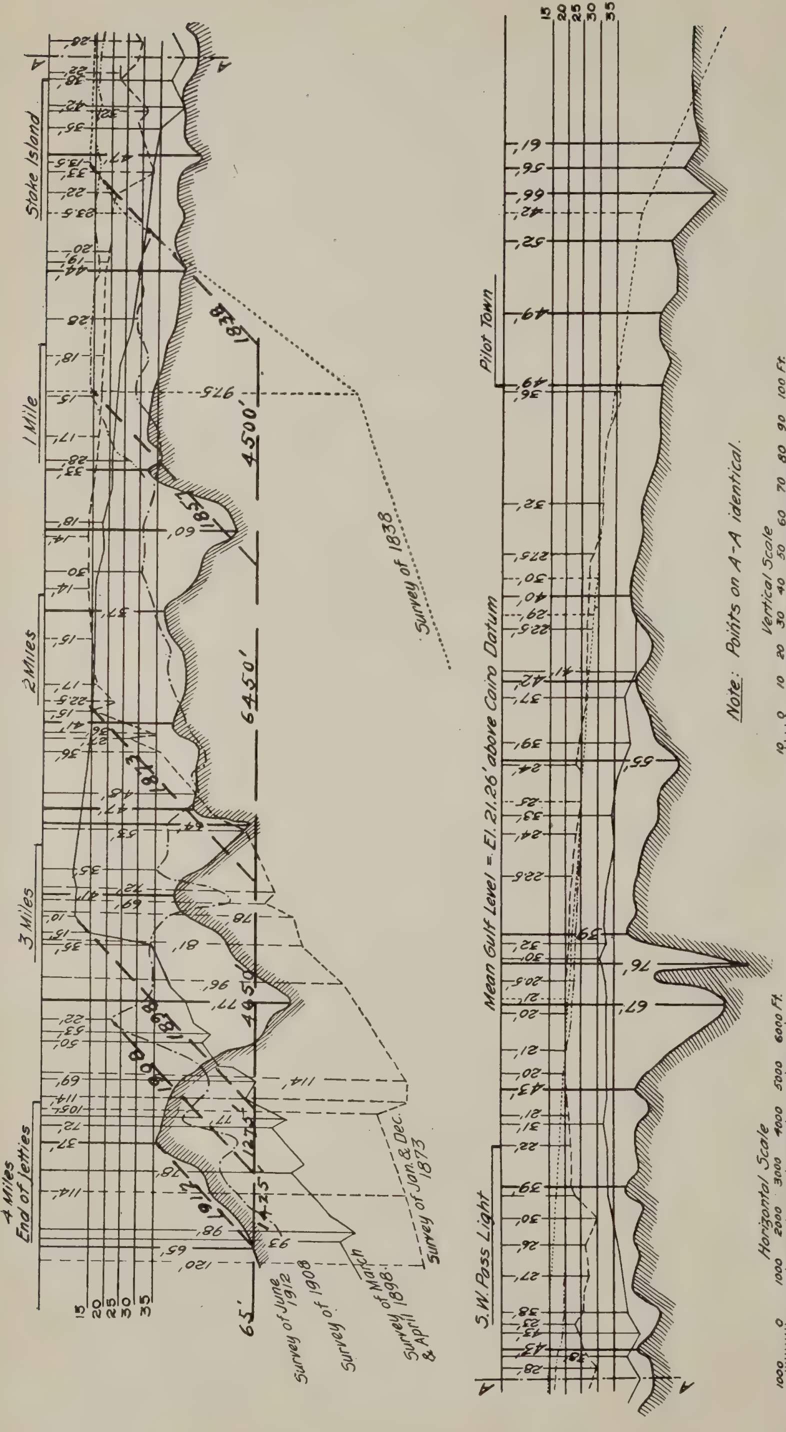
Stake Island
1 Mile
2 Miles
3 Miles
4 Miles
End of Jetties
A
A
15
20
25
30
35
4500'
6450'
4950'
65'
1838
1853
1873
1898
1908
1912
Survey of 1838
Survey of June 1912
Survey of 1908
Survey of March & April 1898
Survey of Jan. & Dec. 1873
Pilot Town
S.W. Pass Light
Mean Gulf Level = El. 21.26' above Cairo Datum
Note: Points on A-A identical.
Vertical Scale
10 0 10 20 30 40 50 60 70 80 90 100 Ft.
Horizontal Scale
1000 0 1000 2000 3000 4000 5000 6000 Ft.

Fig. 2. Profile of Bar at mouth of Southwest Pass, Mississippi River, showing position of crest of Bar on different dates and construction progress of jetties.

weirs would automatically cease to operate at the desired elevation chosen for the weir crest slightly above bank full stage.

In 1874, Mr. Eads made a proposition to improve the entrance to the Mississippi River by jetties at Southwest Pass for $10,000,000, payment to begin when a depth of 20 feet was secured, and continuing as the depth increased to about 28 feet, when $5,000,000 was to have been paid. The remaining $5,000,000 was to be paid in ten equal annual installments, conditioned on the permanence of the channel. A Board of Engineers was appointed to report the best plan of securing and maintaining depths adequate for the commerce of the river by lateral canal, or by deepening one or more natural outlets. This board recommended the use of parallel jetties at South Pass of the same dimensions as those on which they were later built. Congress entered into a modified agreement with Mr. Eads, and in 1879 the jetties were finished. The required depth was generally maintained with the assistance of dredging for five years thereafter, although there were periods each year when the required depth of 26 feet was not available.

The action of the South Pass bar up to this time has been more favorable than there was any reason to suppose would be the case, but the behavior of the Southwest Pass bar leads to the con-

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Key to Illustration on Page 14.

The dotted line is Capt. A. Talcott's survey from February to July, 1838.

The line shown by a dash and two dots is Col. S. A. Long's survey in 1857.

The line shown by short dashes is Capt. C. Howell's survey in January and December, 1873.

The fine solid black line is J. A. Ockerson's survey in March and April, 1898.

The line shown hachured is Lieut. Col. Lansing H. Beach's survey, June, 1912.

The line indicated by a single dash and single dot, Col. Beach's survey of June, 1908.

The *crest* of the bar moved as follows:

1838-1857 (19 years) 4,540 feet, or 239 feet per annum.
1857-1873 (16¾ years) 6,720 feet, or 401 feet per annum.
1873-1898 (24¼ years) 4,280 feet, or 176 feet per annum.
1898-1912 (14 1-6 years) 5,200 feet, or 367 feet per annum.

The *65-foot depth line* on the bar moved as shown in the following table and as shown in the illustration by heavy broken lines.

1838-1857 (19 years) 4,500 feet, or 237 feet per annum.
1857-1873 (16 years) 6,450 feet, or 403 feet per annum.
1873-1898 (25 years) 4,650 feet, or 186 feet per annum.
1898-1908 (10 years) 1,275 feet, or 128 feet per annum.
1898-1912 (14 years) 2,700 feet, or 193 feet per annum.
1908-1912 (4 years) 1,425 feet, or 356 feet per annum.

clusion that when the original conditions are restored at South Pass the yearly rate of extension will be greatly increased. The time required to restore the normal condition at South Pass may be as much as 50 years in the future, and in the meantime the improvement is generally successful. It seems evident from the behavior of the two passes that a relatively small channel discharging a small volume of water is much more easily maintained than is the larger channel where the jetties must be placed much further apart and where the amount of material discharged is much greater. Therefore, in similar improvements, the smallest width of channel between jetties which can fill the needs of commerce should be chosen and, consequently, a minor outlet having small discharge should be used for the improvement.

The constant expansion of the commerce through New Orleans soon necessitated an increase of depth of channel from the river to the Gulf, so that an agitation was begun to improve Southwest Pass. The total length of Southwest Pass from its head to the crest of the bar beyond its mouth is 19 miles. From its head downstream for a distance of 2 miles the average width is 1,890 feet; for the next 7 miles 1,360 feet, and beginning at the ninth mile from the head it gradually widens out until it reaches a width of 4,300 at the east point, the extreme end of its eastern bank. Throughout the narrow portion of the pass the depth is all and more than could be desired, the maximum in each section being about 75 feet, but as it widens the depth becomes less. At Customhouse Bayou, about 11 miles below the head of the pass, the width

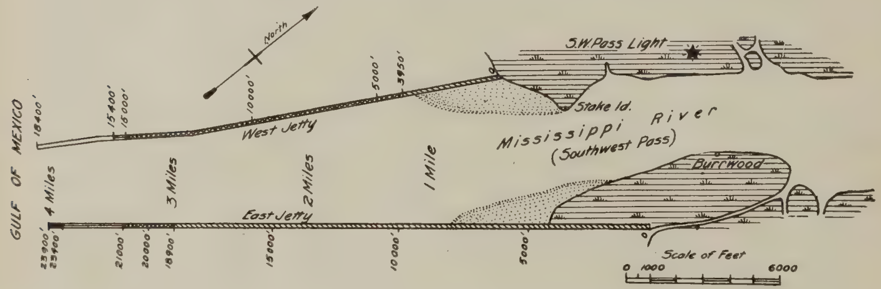

North
S.W. Pass Light
GULF OF MEXICO
18400'
15400'
15000'
10000'
5000'
3950'
Stake Id.
West Jetty
Mississippi River
(Southwest Pass)
Burrwood
4 Miles
3 Miles
2 Miles
1 Mile
East Jetty
23900'
23400'
21000'
20000'
18900'
15000'
10000'
5000'
0
Scale of Feet
0 1000 6000

Fig. 4. Southwest Pass, Mississippi River, June 30, 1912. That portion of both jetties indicated by single hatching was done by contract between January 1, 1904, and June 30, 1907; that by double hatching was completed under same contract between June 30, 1907, and January 4, 1908; that by three lines was completed between November 29, 1909, and June 30, 1912; and that by solid white and solid black between June 30, 1912, and October 17, 1912.

is 2,400 feet, and the 35-foot channel is 900 feet wide. The entrance or the middle of Southwest Pass from the river above is obstructed by shoals a mile long, of which the depth, previous to improvement, was only 31 feet.

Under the act of February 17, 1898, a Board of three Engineer officers was appointed to make a survey of the practicability of securing a navigable channel of adequate width and of 35-foot depth at mean low water of the Gulf, throughout Southwest Pass. The Board reported January 7, 1899, and recommended as follows:

1. Jetties 2,400 feet apart to 30 feet of water in the Gulf with contracting works inland from their land ends. Jetties to be of riprap on mattress foundation, slopes 2 on 3, with top 4 feet above mean low water, large blocks of stone to form cap.

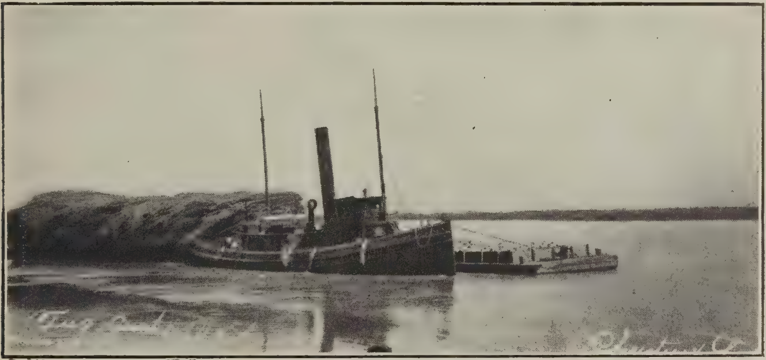


Fig. 5. Tug towing two barges, one loaded with willows and one with stone for ballast for mattresses.

2. Levees from head of Passes to jetties and closure of outlet bayous.
3. Sill across Pass A'loutre.
4. Spur mattresses every 300 feet on channel side of jetties, to prevent undermining.
5. Two powerful hydraulic dredges.
6. Total cost, estimated, $13,000,000.

The 1898 Board having reported that it was practicable to secure the necessary channel, the River and Harbor Act of March 3, 1899, provided for the appointment of a Board of four engineers, two from the army and two from civil life, to prepare and submit a project with estimates of cost to secure suitable width and 35 feet depth throughout Southwest Pass; and to report especially why it was necessary to construct inside jetties.

It was found by this Board from a consideration of the natural conditions in the pass that a channel 1,000 feet wide would be adequate and that its maintenance would be practicable. To secure this channel it was not thought advisable to produce the necessary scour by contraction works, because these, although finally increasing scour, would equally obstruct the flow and decrease the volume until the scour should have occurred, thus causing the other passes to take increased proportions of the total. Moreover, since the depth and width depend on the volume of flow, the channel would silt up before the beneficial effect of the contraction works could be realized; this actually occurred in the South Pass improvement. The Board further recommended the purchase of a hydraulic dredge of large capacity to open and help maintain the channel.

It was proposed to build the jetties slightly converging, and far enough apart so that the foundation would be in shallow water, and hence the work would be much less costly than jetties in 30 or 40 feet of water. The foundation was to consist of flexible mats laid over the entire length and 1,000 feet beyond the proposed depth before the work should begin. They should be at least 2 feet thick, and at least 150 feet wide, covered with about 70 lbs. of rock per square foot. These foundation mats were designed to prevent the jetties from being undermined by current or wave action. Aided by a timber grillage to be placed on top of them, they were to distribute the load so as to bring it down to a safe limit, assumed to be 300 pounds per square foot, for the extremely compressible material on which the structures were to be placed. Monolithic blocks of concrete of the following section were to be built on the grillage before sinking: 12 feet wide on the bottom, 4½ feet thick, 8 feet wide on top, one end being vertical and the other having a slope of about 1 on 1, except the bottom foot, which was to be vertical. The estimated cost of the work, including closure of outlets and dredge, was $6,000,000.00.

The project submitted was adopted by the River and Harbor Act of June 13, 1902, and $750,000 was appropriated, and continuing contracts were authorized to the amount of $2,750,000. The Secretary of War was authorized to modify the Board's plans as found necessary and this was done in a number of minor particulars previous to and during the work.

A steel hull, twin-screw suction dredge was completed for the work on June 28, 1904, at a cost of $209,317.26.

On June 30, 1903, the contract was let to Christie & Lowe for the construction of two jetties, the east one 4 miles and the west one 3 miles long, for $2,824,905.97. The contractor assembled the following plant in the fall of 1903:

850 feet of wharf;

22 buildings of various sizes for officers' quarters, storehouses, shops, etc.

16,200 feet of narrow-gauged railroad track was built, 8 feet above mean high water.

The equipment of the railroad consisted of two locomotive engines, 8 tons each, and forty 5-ton cars.

The floating plant consisted of three tugs, 1 stern-wheel steamer, 1 yacht, 2 launches, 1 quarter-boat, 2 derricks, and 2 pile drivers; besides the plant located at their quarry in Alabama.

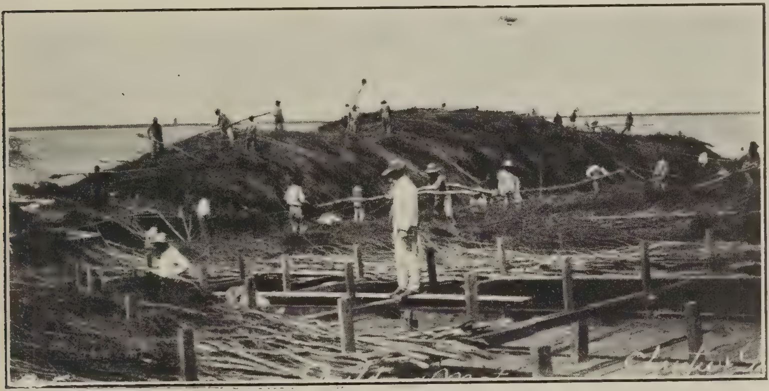


Fig. 6. Constructing mats on ways near railroad yard.

The work began on December 31, 1903, and by July, 1904, 13,400 feet of foundation mats in the east jetty had been placed. Twenty-eight placed on mud before high water were built in situ and loaded with 40 pounds of rock per square foot. The remainder were built on ways and towed to position and sunk with 50 pounds of rock per square foot. The framed mattresses used were essentially of the type used by the Fourth Mississippi River District (lithograph opposite page 18). These mattresses have considerable flexibility and strength, and when constantly submerged in mud will last indefinitely, but are subject to teredo attack above the mud. Each joint of the frame is fastened with a wooden treenail, in addition to spikes and wire strands, so as to be independent of corrosion. Instead of having a grillage of timber, as was originally planned on the foundation mattresses, additional layers of mattress are superposed in gradually decreasing widths, thus bringing the mattress work to about mean high water. On these foundations the concrete superstructure was built. When the foundation layer of mattresses had reached 22,100 feet from the shore end, the three outer ones moved from their original positions after having been in position one to three weeks. The end one moved 100 feet seaward, the sea end swinging eastward about 70 feet. The sea end of the next one moved to the east 35 feet, and the third moved a less distance. At the time of this movement, they were covered with from 1 to 10 feet of sand, indicating the extensive littoral movement of sand. It was found that 40 pounds of rock on the first mattress would sink it into the bottom about two-tenths of a foot. The surface mats were found to be compressed as much as one-tenth of a foot by the weight of the rock. In May, 1906, it was found that three foundation mattresses sunk in 13 to 20 feet of water in November, 1905, at the sea end of the east jetty and loaded with 133 1-3 pounds of stone per square foot had settled 34 feet, although the depth of water over them was practically unchanged. In other words, there was at that time 34 feet of sand deposited on these mats, showing the remarkable foundation conditions encountered. Since completion, the mean settlement of the jetty has been about ¼ of a foot per year.

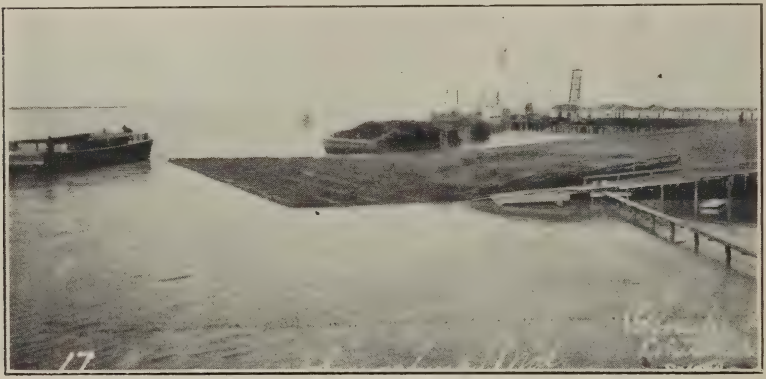


Fig. 7. Launching completed mats.

The contract with Christie & Lowe for the construction of the jetties was completed in January, 1908, there having been constructed approximately 1,000,000 square yards of mattress, using 328,000 tons of stone and 44,500 cubic yards of concrete. Under a contract with Christie & Lowe the work of extending the east jetty 3,000 feet and the west jetty 3,750 feet was commenced in April, 1911, and completed in October, 1912, at a cost of $704,-958.34. The pass was opened to navigation December 20, 1911.

Fig. 3 (opposite page 15) shows graphically the rate of travel of the bar from 1838 to 1912, indicating the wide variation of the rate of advance at different periods since the first survey was made in 1838. A large increase in the rate of advance of the bar is also apparent since the jetties were started. In accordance with the opinions of those engineers who maintained that jetties would largely increase the travel of the bar, the conduct of the Southwest Pass bar has been the reverse of that at South Pass, where the rate of advance has decreased since the jetties were built. The scouring capacity of Southwest Pass with its jetties complete, may be sufficient to keep open the dredged channel by carrying the heavy material far out into the deep water of the Gulf, and thus reduce the rate of bar advance. It is a notable fact that successive bars previous to 1898 were at about the same elevation, namely, 14 feet below mean Gulf level; the 1898 bar was 4 feet higher, giving only 10 feet of water at mean Gulf level; in 1908 there was 22 feet over the bar and in 1912 there was 37 feet, secured by the constant operation of two powerful sea-going dredges. The Gulf-side slope of the bar at different periods has remained practically unchanged at about 1 on 85. It is probable that some further con-

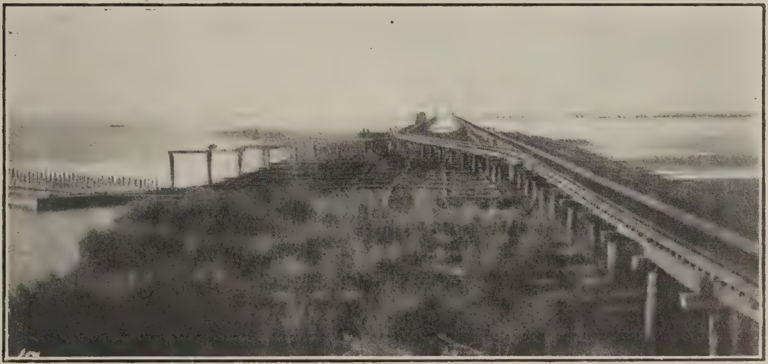


Fig. 8. Track on to jetty; inner mats in place and frames for mats on barges at left.

traction of the channel near the outer ends of the jetties by means of spurs or by extending and drawing in the ends will be desirable in order that the scouring capacity of the current may be increased sufficiently to maintain the required 35-foot depth. It appears that the jetties should have been located about 2,000 instead of 3,500 feet apart at their outer ends. On account of the unusual features connected with the work at South Pass and Southwest Pass, it is unfortunate that more frequent detailed surveys have not been made on the bars.

DEVELOPMENT OF THE PORT PROPER.

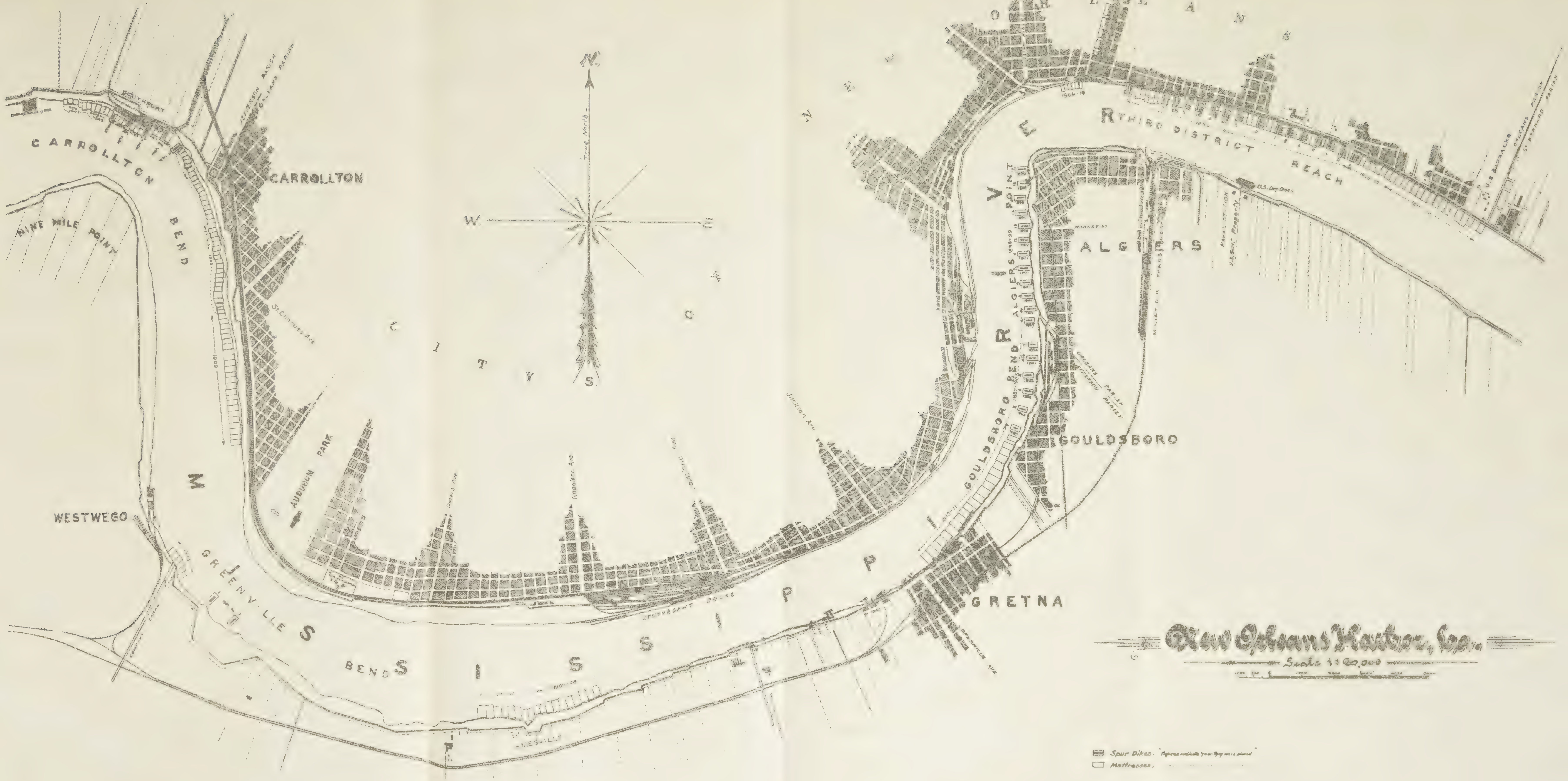
The port proper of New Orleans is about 100 miles from the Gulf of Mexico, and extends about 15 miles on the Mississippi, including both banks (lithograph between pages 22 and 23). On the east bank over 17 miles and on the west bank 22½ miles of available water front is under control of the port authorities. There are about 6 miles of wharf on the east bank, all of which are under the control of the Board of Dock Commissioners of the City of New Orleans, with the exception of the following private wharves:

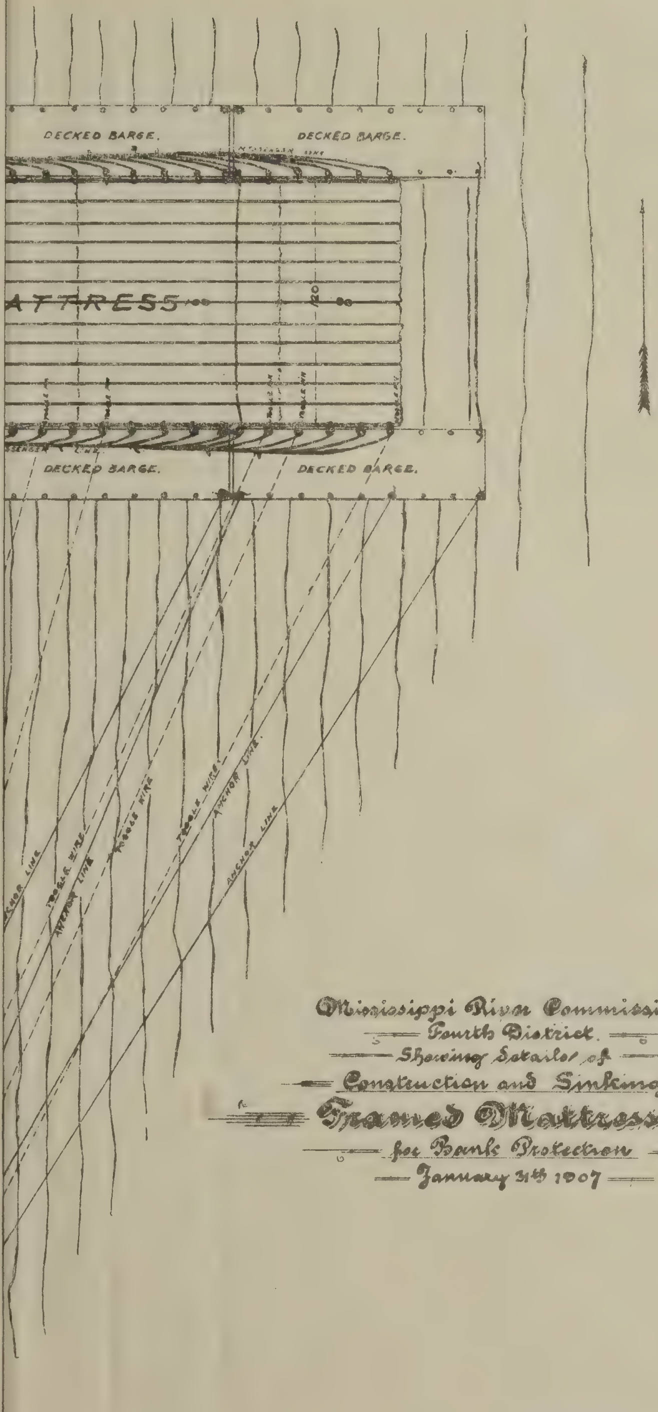
On the west bank: U. S. Naval Station, Southern Pacific (2), Murphy Lumber Company, Union Oil Company, Southern Cotton Oil Company, Seaboard Refining Company, J. M. Guffy Petroleum Company, Louisiana Cypress and Lumber Company, Swift & Company, Penick & Ford, Limited; Texas Oil Company, Texas & Pacific Terminals at Westwego.

On the east bank: The Chalmette Slips, L. & N. R. R. Co., Texas & Pacific Railway Company, Stuyvesant Docks, Columbia Oil Mill and the U. S. Engineer Depot.

All of these grants are subject to expropriation when the interests of commerce require it, and nearly all of the private wharves are in unused portions of the harbor. The Chalmette slips above mentioned are the only slips in the harbor and have been a disastrous failure on account of defective foundations and poor location, causing a large amount of silt carried by the river rapidly to fill up the slips so as to make them useless, except at a large expense for continuous dredging. It is on account of this large amount of sediment carried in the Mississippi River that all of the wharves are arranged for ships to lie alongside instead of in slips, as found at most large ports.

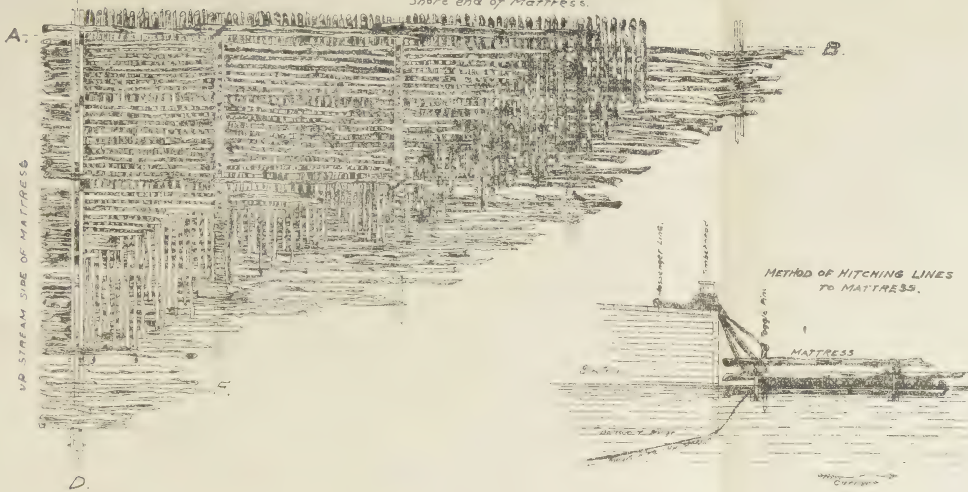
Previous to 1879 there was no effort made to improve the natural condition of the harbor proper by fixing the position of the


New Orleans Harbor, La.
Scale 1:20,000
N
W
E
S
True North
NEW ORLEANS
CITY
MISSISSIPPI RIVER
CARROLLTON
CARROLLTON BEND
NINE MILE POINT
SOUTHPORT
JEFFERSON PARISH
ORLEANS PARISH
St. Charles Ave.
AUDUBON PARK
Napoleon Ave.
Jackson Ave.
STUYVESANT DOCKS
WESTWEGO
GREENVILLE BEND
MCDONOGH
GRETNA
GOULDSBORO
GOULDSBORO BEND
ALGIERS
ALGIERS POINT
THIRD DISTRICT REACH
U.S. Dry Dock
Naval Station
U.S. Gov't Property
U.S. Barracks
ORLEANS PARISH
ST. BERNARD PARISH
Spur Dikes. "Figures indicate year they were placed"
Mattresses.


DECKED BARGE.
DECKED BARGE.
MESSENGER LINE
ATTRESS
120
MESSENGER LINE
DECKED BARGE.
DECKED BARGE.
TOGGLE WIRE
ANCHOR LINE
TOGGLE WIRE
ANCHOR LINE
TOGGLE WIRE
TOGGLE WIRE
ANCHOR LINE
ANCHOR LINE

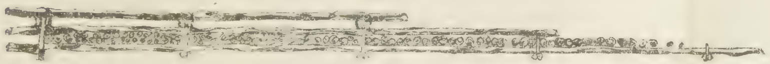
Mississippi River Commission.
Fourth District.
Showing Details of
Constuction and Sinking
Framed Mattresses
for Banks Protection
January 31th 1907

PLAN OF MATTRESS.

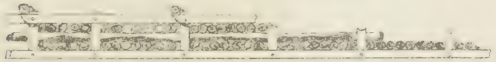

C.
E.
Shore end of Mattress.
A.
B.
UP STREAM SIDE OF MATTRESS
F.
D.
Toggle Pin
MATTRESS
Water Surface
Current

METHOD OF HITCHING LINES TO MATTRESS.

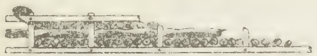
SECTION THROUGH A-B.



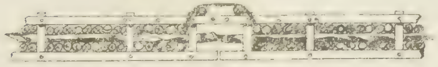
SECTION THROUGH C-D



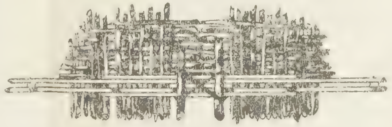
SECTION THROUGH E-F.



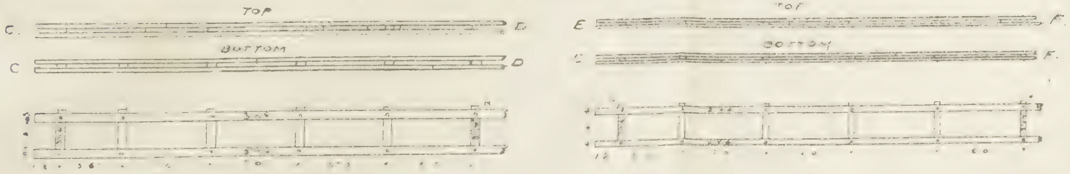
SIDE VIEW
METHOD OF CONNECTING SECTIONS.

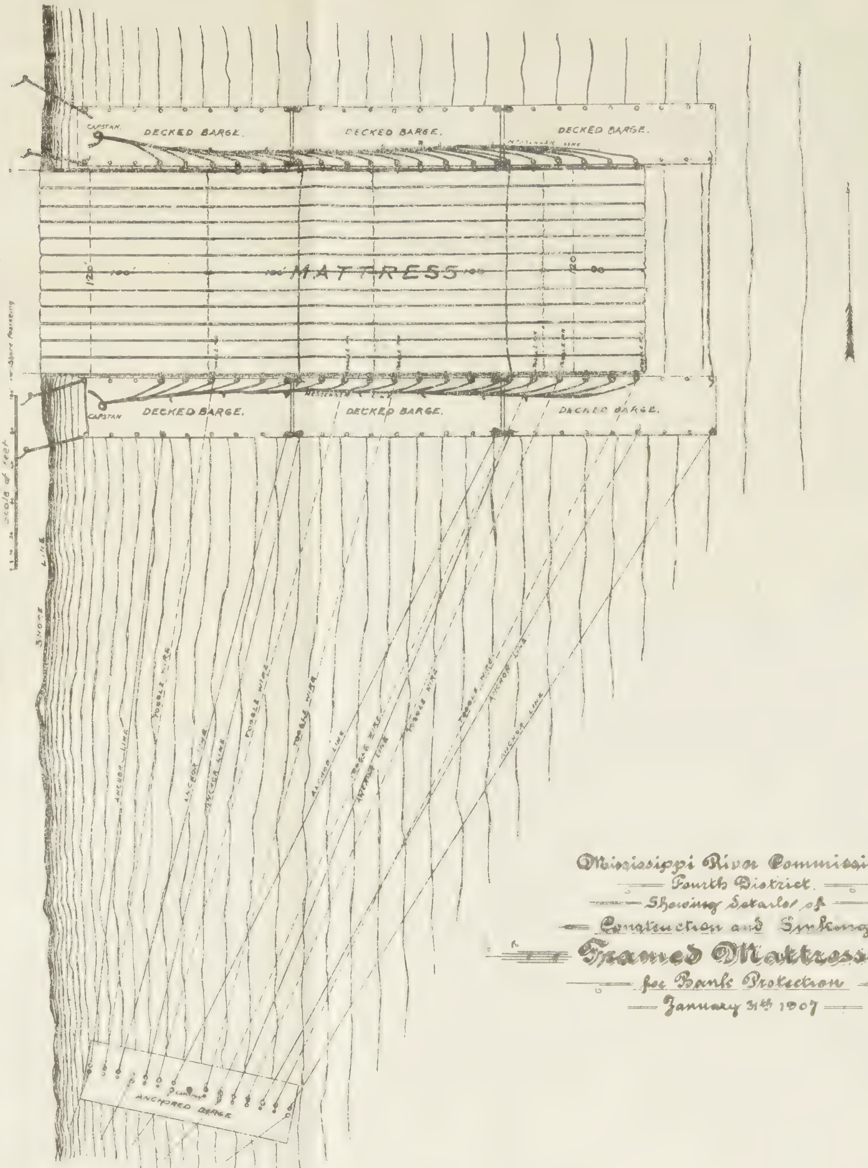


TOP VIEW.
METHOD OF CONNECTING SECTIONS



PLAN AND ELEVATION OF FRAME WORK OF MATTRESS


TOP
C.
D
BOTTOM
C
D
E
F.
TOP
BOTTOM
E
F.


CAPSTAN.
DECKED BARGE.
DECKED BARGE.
DECKED BARGE.
MATTRESS
120'
100'
CAPSTAN
DECKED BARGE.
DECKED BARGE.
DECKED BARGE.
SHORE LINE
ANCHOR LINE
TOGGLE WIRE
ANCHOR LINE
ANCHOR LINE
TOGGLE WIRE
ANCHORED BARGE.

PLAN
Showing Method of Holding Mattress when sinking it.
Scale of feet

Mississippi River Commission
Fourth District.
Showing Details of
Construction and Sinking
Framed Mattresses
for Bank Protection
January 31st 1907

channel and increasing the stability of its banks. In April, 1877, a commission of six engineers, three of whom were officers of the Corps of Engineers, U. S. Army, made a survey and examination of the harbor for the mayor of New Orleans to secure the following information:

1. A thorough and complete survey of the river and its banks from the upper to the lower limit of the city, giving cross sections of the stream each half mile and the direction of the current.

2. A plan for the temporary preservation of its banks and wharves from destruction, to apply only to the most exposed points and adapted to the resources of the city, with estimates of cost.

3. More general and comprehensive plans embracing the river front of the second and third districts as a permanent work, so as to be commenced and carried on gradually as the prosperity of the city might warrant.

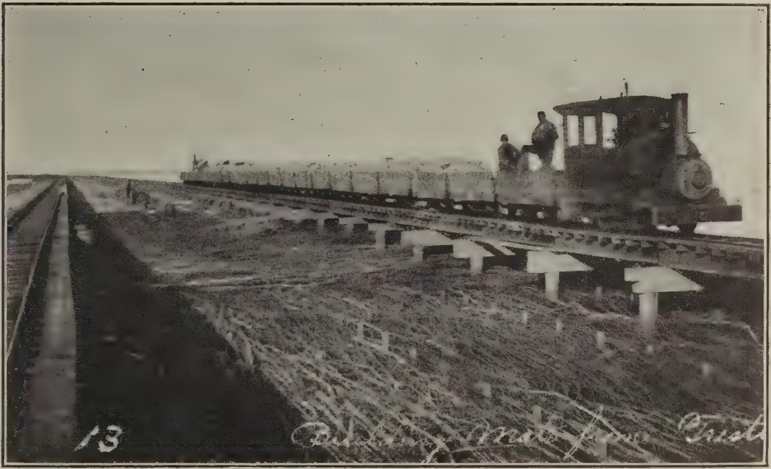


Fig. 9. Construction in situ of inner mats, showing train with rock for ballasting

A preliminary report in 1877 gave the steps necessary to temporarily protect certain exposed points; this was followed by a full report on April 8, 1878, based on extensive surveys and borings, recommending improvements at a total estimated cost of $476,000.00. Unfortunately, these maps were not printed and consequently a most valuable source of information on the early hydrographic condition of the harbor was lost. The conclusions of this Board were so well founded that to-day a full report on the improvement of the harbor could not make more correct deductions and recommendations than the following taken from this report: ''Results of the survey of the banks show that they are composed of hard, blue mud with intermediate soft strata. These soft strata occur at various depths, as shown on adjacent lines of soundings. In some cases they are quite regular, in others quite irregular, as if deposited upon a slope. The cavings result from the saturation of these layers, which are afterward washed or cut out, causing the superincumbent mass to fall or slide into the river. This caving takes place mostly on a falling river, the high water seeming to act by its pressure in sustaining the bank. These soft strata occur at various depths from near the surface to near the bottom of the river, and a greater or less amount of cave seems to depend upon their relative position. Then, to retain the bank in its natural position the remedy to be applied would seem to be some method by which the cutting out of the defective strata could be prevented. This is best accomplished by applying to the bank a revetment extending so as to cover the whole slope, or so much of it as is likely to be affected.''

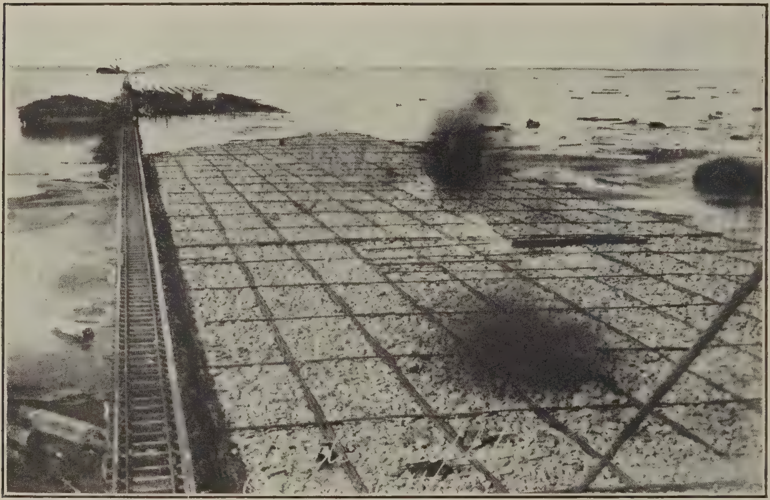


Fig. 10. Inner mats, complete with ballast.

That the conclusions of this Board have been justified by experience is shown by the fact that the present successful project is essentially along the lines originally proposed. Deductions as to character of banks and causes of caves and subsidences have been

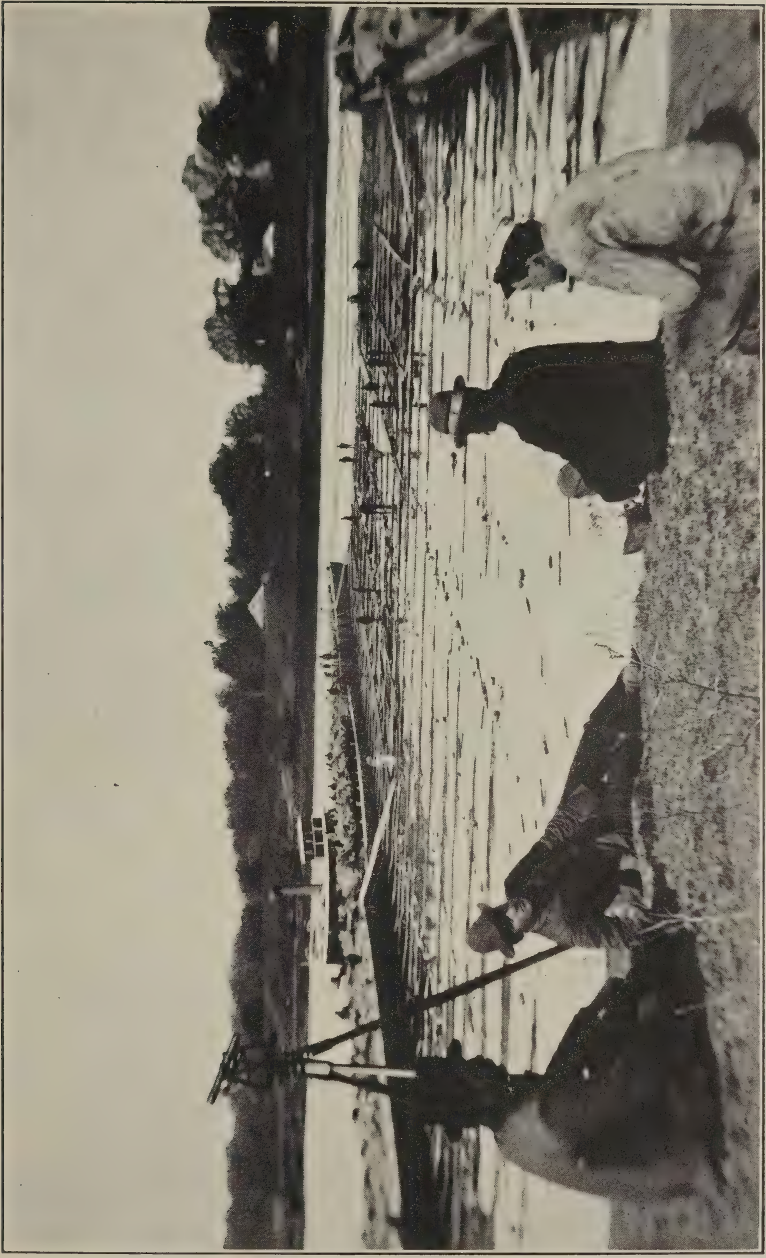


Fig. 11. Mattress, 150 by 300 feet, partly ballasted and ready to sink.

recently confirmed by the investigations of a Board of Engineers examining into the caves occurring late in 1912 in the lower part of the harbor.

The Board of 1877 recommended bank revetment of brush mattresses and these were at first constructed 24 feet wide with a net covering width of 14 feet, and extending out into depths of 50 to 80 feet. Comparing these mats with the ones of to-day, 150 feet wide and extending out into depths as great as 150 feet, shows the development of this system of bank protection. The mats or carpets were made of ''fish-pole cane.'' These were woven into carpets 1 or 2 inches in thickness, 25 feet long and 24 feet wide. Eight of these were then joined together to form a carpet 200 feet long and ballasted with bags filled with sand, the joints of cane being pierced to destroy its buoyancy. The carpet, 200 feet long, being ready for sinking, was attached to the piling by iron rings and the ways barge then moved by tugboat into the stream, launching the carpet as it went. The cost of this very thin and perishable revetment was about 14 cents per square foot, as compared with 7 cents for the present type of framed mattress, containing 16 inches thickness of compressed brush. Work of protecting the banks in the harbor has steadily continued from that time up to the present, until now there are 45,715 linear feet of the 40 miles of bank line in the harbor protected either by spur dikes placed about 450 feet apart or by continuous bank revetment. This work is placed as follows:

In Carrollton Bend, protected for 11,295 feet by continuous mattresses, and for 2,335 feet by five spur dikes in conjunction with continuous mattress.

In the Greenville Bend near Amesville, for 4,050 feet, and at Westwego for 1,500 feet by continuous mattresses.

On the Gretna Front, for 5,010 feet, by continuous mattress.

In the Gouldsboro Bend, for 9,475 feet, by 24 submerged sloping spur dikes.

In the Third District Reach for 1,110 feet, by continuous mattresses, and 1,290 feet by continuous mattresses in conjunction with 16 submerged sloping spur dikes (see fig. 14, page 29, for type of spur dikes).

There remains to be protected 18,500 feet of caving bank. It was found that between certain spurs erosion was active, consequently continuous revetment has been placed in these intervals. The work being done at present is continuous revetment by means of framed mattresses of the type shown in Fig. 11, page 25. The method of construction of these mats is shown in the illustrations. The construction ways are built on a sand bar, accessible to growing willows in sufficient quantities to build a number of sections (150 by 100 feet) of mattress. One of the greatest advantages of the framed over the fascine or woven mattress is the possibility of constructing it on the willow bars instead of at the site of the sinking. The construction ways are given a slope of about 1 on 6, so as to allow the mat when finished to slide easily into the water. It is desirable to secure a site where there is approximately the natural slope of the bar, to save the labor required in lifting the willows up to the ways. The frames are then built and spaced, and on these the willows are closely placed in three checkerboard layers and nailed to the frames. The caps are then placed on the stanchions (verticals), and by means of specially designed jacks these top frames are forced down until the frames are tightly compressed, when they are secured by spikes and tree nails.

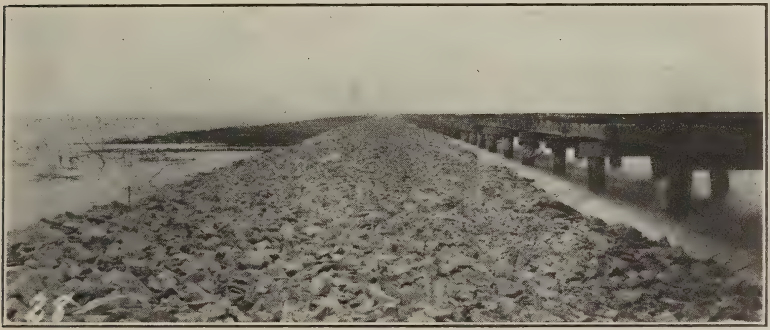


Fig. 12. Completed inner jetty, there being no concrete cap on this part.

Having been constructed and launched, a tow of eight or ten sections is formed and towed to the vicinity of the site for sinking. Before sinking, three of the mats are securely fastened together, making a mat 150 feet along the bank by 300 feet into the stream. Barges are then placed on three sides of the mat, and each of the framed pockets is loaded by wheelbarrow-men with enough stone to overcome flotation. A loaded barge is then towed over the mat and additional stone (in all, about 15 pounds per square foot) is cast from the barge to the mat until it gradually sinks to the bottom, being secured to the bank by galvanized wire cables attached to dead-men on the shore. The following is a condensed description of the improvement work in New Orleans Harbor by years, as furnished in official reports:

1885 . . . Spur dikes Nos. 2 and 3 were fully, and No. 5 about half, completed in Gouldsboro Bend; 210,000 square feet of woven mattresses were placed at an estimated cost of 7.6 cents per square foot; 465,036 cubic feet of crib work was placed, at an estimated cost of 3.6 cents per cubic foot. The total cost of the work for the year was $87,006.35.

1886 . . . No work done; lack of funds.

1887 . . . Spur dikes Nos. 1 and 6 were completed in Gouldsboro Bend and the cribs to complete Spur No. 5 left unfinished in 1885 were made; 102,600 square feet of mattress and 377,874 cubic feet of cribs were built, but no statement of cost per foot was furnished. The total cost of the work for the year was $40,299.47.

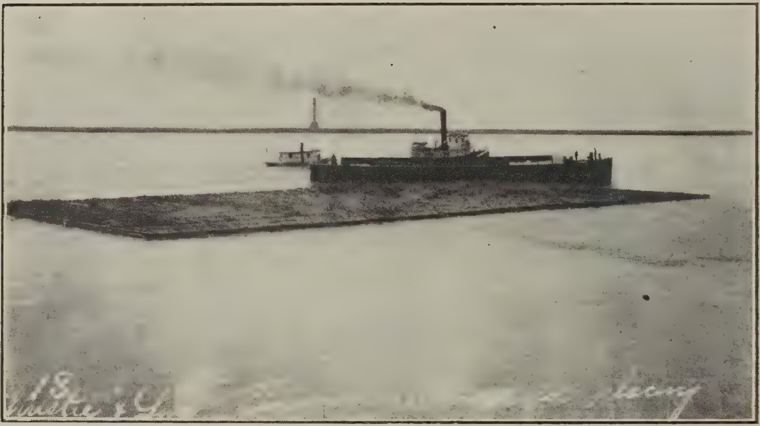


Fig. 13. Towing mats to site of sinking.

1888 . . . Spur dike No. 4, Gouldsboro series, was completed; No. 5 was completed and No. 6 repaired. Total square feet of mattress completed, 52,500; and total cubic feet of crib work, 416,020. Crib work per square foot, 4.57 cents; mattress, per foot, 9.11 cents. Cost for the year, $33,180.44.

1889 . . . Spur dike No. 1, Greenville Bend, was nearly completed; 68,500 square feet of mattress and 188,670 cubic feet of crib placed. Crib work, 4.02 cents per cubic foot. Woven mattress, 6.39 cents per square foot. The framed mattress now standard in this work was first used this year on the outer end of Spur No. 1, as the

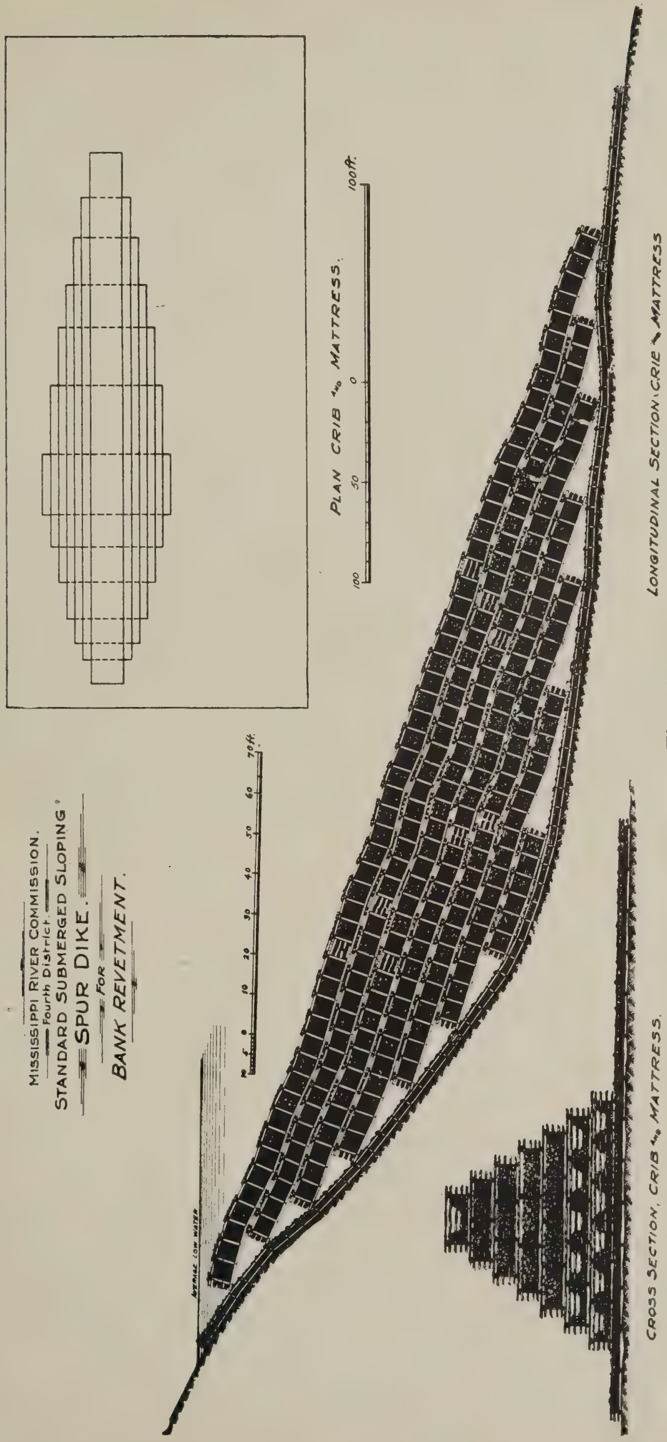

MISSISSIPPI RIVER COMMISSION.
Fourth District.
STANDARD SUBMERGED SLOPING
SPUR DIKE.
FOR
BANK REVETMENT.
10 8 6 4 2 0 10 20 30 40 50 60 70 ft.
AVERAGE LOW WATER
PLAN CRIB AND MATTRESS.
100 50 0 100 ft.
LONGITUDINAL SECTION, CRIB AND MATTRESS
CROSS SECTION, CRIB AND MATTRESS.

Fig. 14.

weaving plant did not admit of weaving a mattress of the required width. These framed mattresses were 140 by 110 feet, and cost 9.56 cents per square foot. Total cost of the year's work, $77,557.31.

1890 . . . Spur No. 1, Greenville Bend, completed. Spur No. 2 finished, and spurs 1, 2, 3 and 4 of the Third District Reach were built; 209,254 square feet of mattress at 7.126 cents per square foot and 974,287 cubic feet of crib work at 3.622 per cubic foot were placed. The woven mattress was finally abandoned this season and the framed mattress adopted. Spurs 1, 2, 3 and 4 of the Third District Reach were raised to the high water mark by rock revetment. Total expenditures, $78,219.33.

1891 . . . Spurs 3, 4, and 5 of Carrollton Bend were built; 152,250 square feet of mattress at 9.87 cents per square foot and 709,666 cubic feet of cribs at 3.59 cents per cubic foot were placed. Total expenditures, $78,688.08.

1892 . . . Spurs No. 1′, 2′, 3′, and 5′ of the Third District Series and Nos. 3½ and 4½ of the Carrollton Series were built. A small mattress was sunk below Spur No. 4, Carrollton Bend, to prevent the spur being flanked by eddy action; 319,200 square feet of mattress at 9.218 cents per square foot, and 890,664 cubic feet of cribs at 3.649 cents per square foot were placed. Total expenditures; $72,951.21.

1893 . . . 652,020 square feet of mattresses were placed in Carrollton Bend at 8.919 per square foot. Total expenditures, $84,768.33.

1894 . . . No work; lack of funds.

1895 . . . Continuous mattress between Spurs 1′ and 2′, Third District Series. Foundation mattresses placed for Spurs 2½′, 3½′, and 4½′ of the same series, together with some small mattresses immediately below Spurs 2′, 3′, 3½′, 4′ and 4½′; 744,000 square feet were placed at 8.326 per square foot. Total expenditures, $93,873.09.

1896 . . . No work; lack of funds.

1897 . . . No work; lack of funds.

1898-1899 . . . Six spurs and two buttresses above Algiers, at 3.79 cents per cubic foot. Foundation mattresses for same, at 7.702 cents per square foot. Total expenditures, $56,017.38. The buttresses mentioned were small cribs without mattress foundation, placed in front of very steep portions of the bank with a view to increasing their stability by the added weight.

1899-1900 . . . No work; lack of funds.

1900-1901 . . . No work; lack of funds.

1901-1902 . . . 460,800 cubic feet of cribs and 360,000 square feet of foundation mats for six spur dikes between Gouldsboro and Algiers Point; 450,000 square feet of mats covering 1,800 feet of Carrollton Bend. Cost of cribs in place, 2.765 cents per cubic foot. Mattress in place, 5.28 cents per square foot.

1902-1903 . . . 157,500 square feet were placed covering 715 feet at Southport, costing 7 cents per square foot.

1903-1904 . . . Southport revetment extended 4,750 linear feet at a cost of $87,375.39. Cost of mattress in place, per square foot, 6.25 cents.

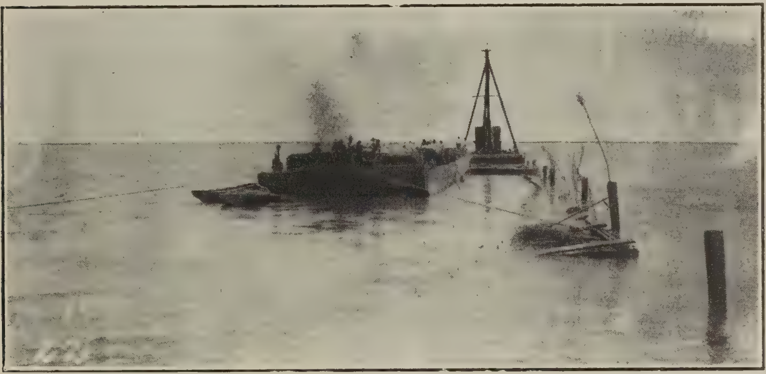


Fig. 15. Piling shows method of aligning mats. View also shows mat being ballasted.

1904-1905 . . . No work; lack of funds.

1905-1906 . . . Two spur dikes were constructed, one 340 feet above and 340 feet below spur of the Gouldsboro Bend series, consisting of 109,500 square feet of mattress and 233,568 feet of cribs at a cost of $37,329.21.

1906-1907 . . . Four spur dikes and three small buttresses were placed in Gouldsboro Bend and 550 feet of continuous subaqueous revetment was placed along the 60-foot contour, Carrollton Bend, at a cost of $61,932.52. As an indication of the difficulty of the work of sinking mats at high water stage of the river the following is quoted from the Annual Report, 1907: "The river had risen to a high stage and was full of heavy drift. On one occasion all of the mooring cables parted and the entire plant sent adrift. On the night of January 3, while the plant and a partially ballasted mattress were in position, a piece of heavy drift or wreckage struck the outer barge and tore off one of the bottom planks. The barge sunk and dumped its load of rock, partially wrecking the mattress and injuring an adjoining barge. The sunken barge was recovered in bad condition, but a portion of the mattress was lost. On another occasion, on account of the accumulation of heavy drift under a mattress, some of the wire cables broke while it was being sunk and a strip on the outer edge dumped its ballast, coming to the surface bottom up.''

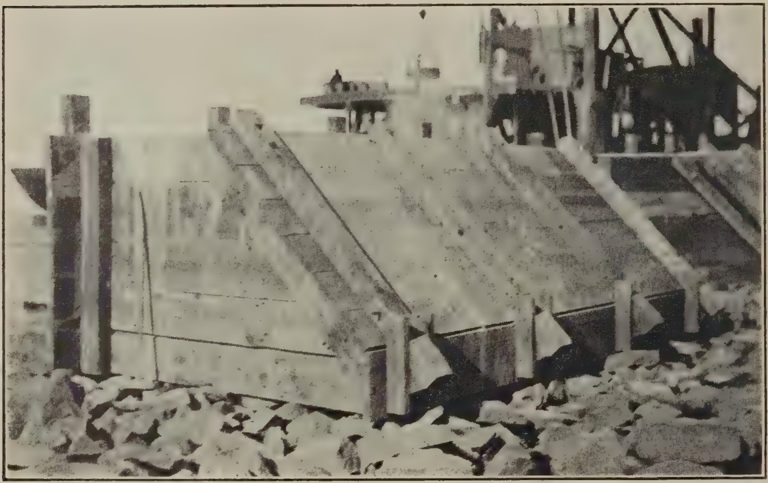


Fig. 16. Mixing and filling plant.

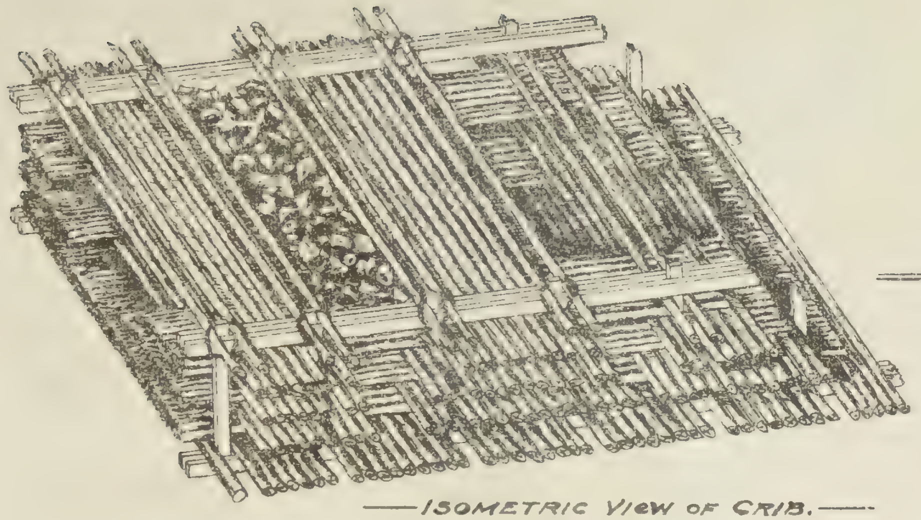
1907-1908 . . . 756,000 square feet of mattress covering 2,470 linear feet of bank 300 feet wide was placed in Greenville Bend at a cost of $92,215.32; cost, $25.93 per linear foot.

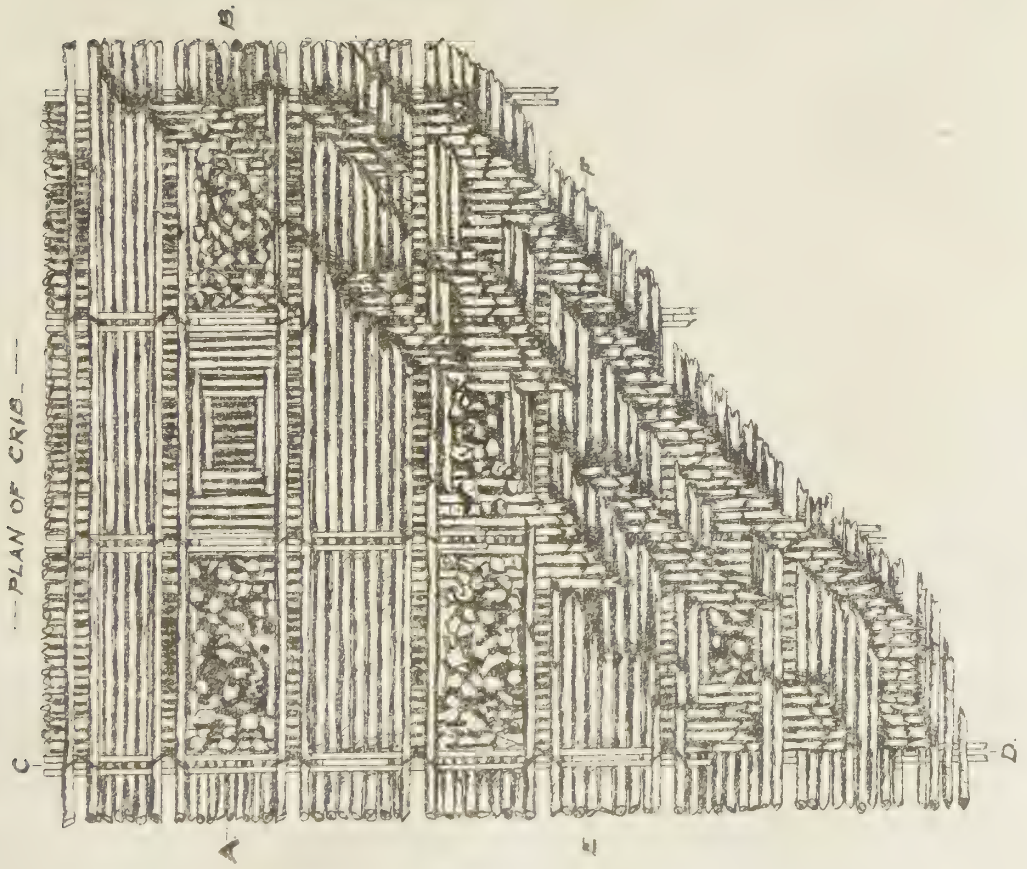
1908-1909 . . . 2,027,500 square feet of mattress were placed in Greenville Bend at a cost of 6.663 cents per square foot.

1909-1910 . . . 1,155,000 square feet of mattress were placed in Carrollton Bend, covering 3,955 linear feet of bank at a cost of 8.24 per square foot.

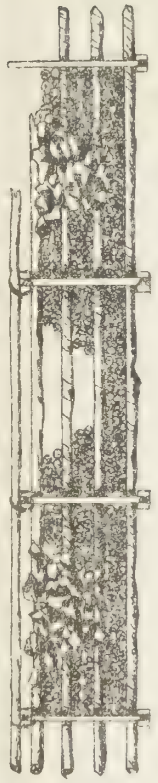
1910-1911 . . . 1,960,000 square feet of mattress, covering 7,850 linear feet of bank, were placed at a cost of 6.75 cents per square foot, of which 2,765 linear feet were on the Gretna front and 3,975 were in Carrollton Bend.

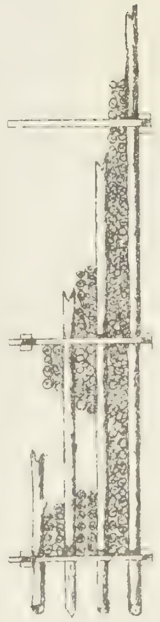
Mississippi River Commission.
Fourth District.
Showing Details of
Construction and Placing
# Submerged Spur Dikes,
# Cribs,
for Bank Protection.
February 1907

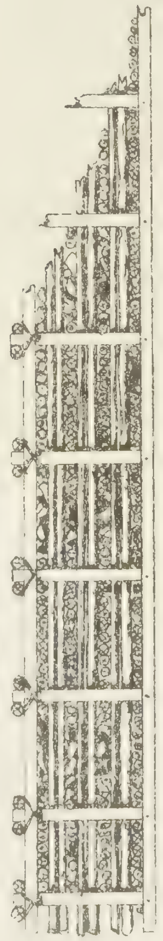

ISOMETRIC VIEW OF CRIB.

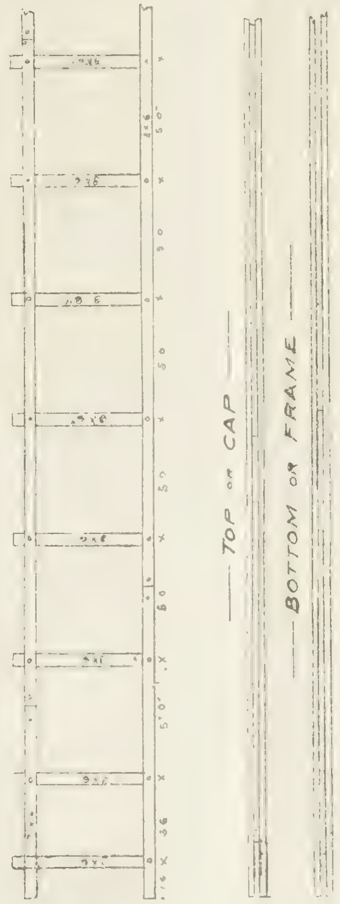


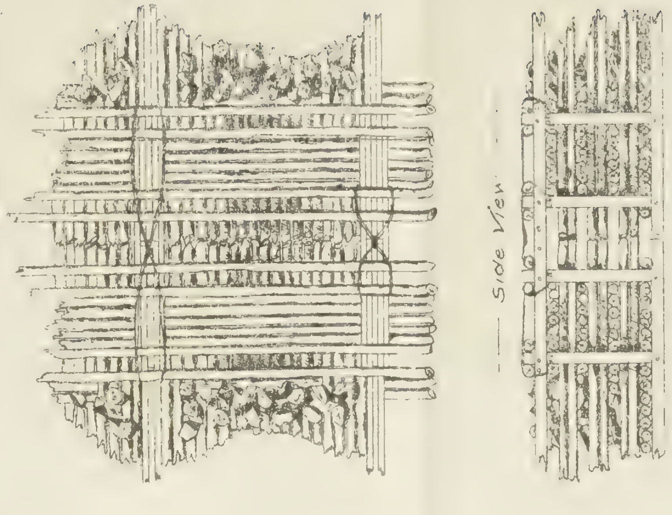
PLAN OF CRIB.

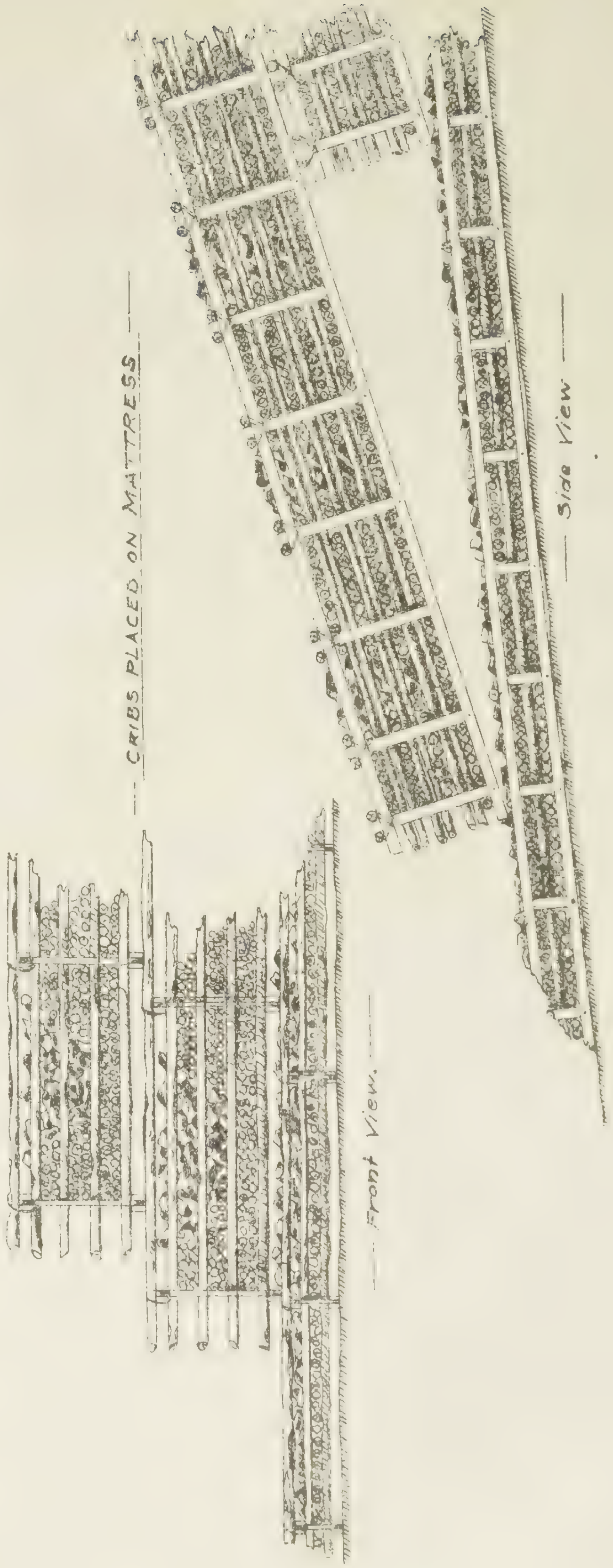

SECTION THROUGH A.-B.


SECTION THROUGH E.-F.


SECTION THROUGH C.-D.


TOP OR CAP
BOTTOM OR FRAME
ELEVATION AND PLAN OF FRAME WORK OF CRIB


Top View.
Side View
METHOD OF CONNECTING SECTIONS


Side View
Front View.
CRIBS PLACED ON MATTRESS

1911-1912 . . . 2,730,000 square feet of mattress, covering 9,965 linear feet of bank were placed at a cost of 6.47 cents per square foot, of which 3,090 linear feet were placed in the Third District Reach, 2,180 linear feet in Carrollton Bend and 2,215 linear feet on the Gretna Front, and 2,480 linear feet in the Greenville Bend.

1912-1913 . . . 450,000 square feet of mattress, covering 1,500 linear feet of bank in Greenville Bend in front of Westwego, at a cost in place of 6.888 cents per square foot.

In all the years since 1878, when this work of protecting the banks of New Orleans Harbor was commenced, the most noticeable feature has been the small and intermittent appropriations, causing the work to be prolonged and the cost to be greatly increased. To have made a complete work, the protection should have begun at the upper end of the harbor and should have been carried downstream continuously to the lower end, protecting all caving banks. This should have been prosecuted at the rate of $300,000 a year instead of at the rate of $61,000 actually used, of which a large part has been required for maintenance of plant and protection of work placed during the long period.

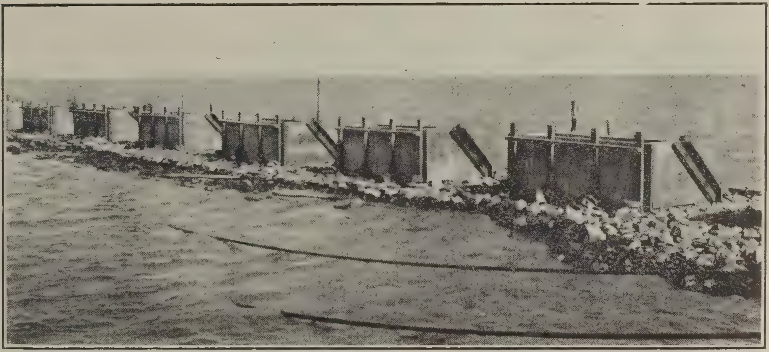


Fig. 17. Forms for concrete monoliths.

The entire section of the Mississippi throughout the harbor, except for local shoaling in front of the Stuyvesant Docks is of ample depths for all requirements of commerce, even along the wharves, there being in some places as much as 150 feet in the thalweg. There is also ample space for all vessels now using the harbor to lie at anchor in the stream, and as the current is uniform in its direction no swinging on the anchors is encountered, nor has any case of a vessel dragging her anchor been noted, the effect of storms being light as compared with the exposed coast harbors. The adequate depths and widths of the harbor renders the city independent of any local channel improvement work, except for bank protection as a means of protecting local interests and of preventing possible destruction of levees and wharves; and, of course, except for the work at the Passes to keep open the channel to the Gulf. The great extension of the public wharf system is now waking the city to the necessity of having all the bank lines definitely fixed to prevent some wharves from being rendered useless by sand bar formation, and others from being destroyed by caving or subsiding banks. Due to the fact that a large portion of the caving portions of the bank have not yet been protected and the consequent inevitable changes to be expected, it has never been deemed advisable to establish harbor lines. In the issue of permits, however, for wharf construction the future necessity of harbor lines is kept in view and a certain uniformity of pier head line is maintained. The difficulty of constructing wharves in the great depths found, and of maintaining them in the unstable and unstratified earth forming the banks has prevented encroachment on the river's section, which at flood is amply able to take care of itself and to provide sufficient section if too much infringed upon.

There are two distinct classes of faults of river bank found in the harbor, as well as generally on the Mississippi. One is known as caving, and the other as subsidence. A caving bank is one that is gradually eroded below low water and usually near the bottom of the bank, until the slope of the bank becomes too steep to carry the load. When this occurs, there is a sudden shearing off of a large mass of earth which is precipitated to the bottom of the river and a large part is then washed away by the current. These caves vary in size up to 1,000 to 2,000 feet long by 400 or 500 feet perpendicularly to the bank. On the lower river they rarely exceed 400 or 500 feet long by 400 feet inland, but even at that the necessity for adequate protection against subaqueous erosion is apparent. Bank subsidences are due to little known causes, and are entirely independent of the erosion or slope of the lower bank They often occur on a making bank and are accounted for as follows: The materials forming the river bank are entirely unhomogeneous, without persistent stratification or uniformity of material. There will be pockets of the hardest clay and others of fine silt so light that borings through them indicate practical voids. When these volumes of light material are near the bank there seems to be a tendency at low stage of the river for the subsoil water to percolate out into the river, carrying the fine silt with it. This continues until finally the volume contains so little solid matter that it loses its supporting power and the upper bank crushes down to fill the void. This character of disturbance has frequently occurred where the bank is stationary or making, and often where mattresses were intact both before and after the subsidences.

Mattresses are only effective in preventing erosion of a bank. They have no strength to actively support an unstable one, and consequently with excessively steep sub-banks found in New Orleans Harbor at several places, notably Westwego and Carrollton, it will not be surprising to see in future, as has occurred in the past, some caves and possibly disastrous ones. It can be said for the mattress work and spur dikes, however, that so far, since inaugurated about 1880, they have been remarkably successful in this harbor. Banks are being held here at slopes which would be considered impossible on the upper river in sandy soils, such as found in Giles Bend and other points.

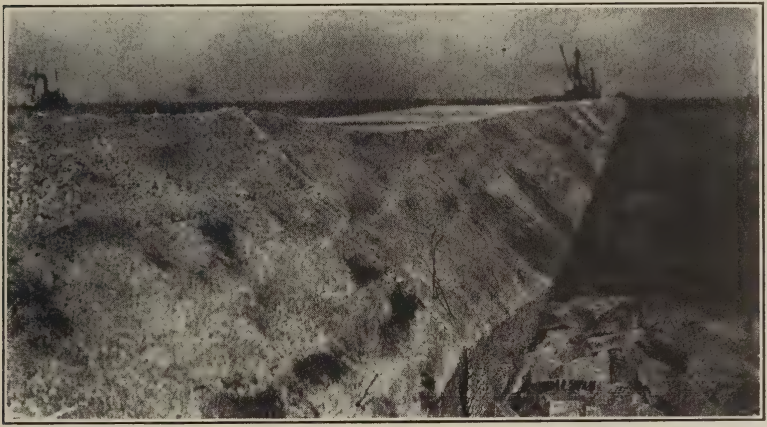


Fig. 18. Completed concrete superstructure from sea side.

One of the greatest handicaps, even the greatest to New Orleans' growth is the menace of the frequent excessive floods in the Mississippi, causing at times the city's level to be as much as 20 feet below the surface of the river, with only large section levees (which are, in reality, wide mounds of earth) to hold back these waters. It speaks well for the energy of the people there that no portion of the city has ever been overflowed from the river.

The experience of the recent highest known floods on the river, namely, that of 1912 and the two of 1913, shows how dangerous it is to build levees closer to the river than about 200 feet. Previous to this time caving at high water was so exceptional that, in 1902, Maj. George McC. Derby was only able to find four cases of high-water caving up to that time. This year, on the contrary, at the highest and most dangerous stage of the flood there occurred a number of caves, two of the worst being at Poydras and at Harris Canal, each about 350 feet along the bank by 350 feet perpendicular to the bank, and both taking out the crown and a portion of the land-side slope of the levee. There are many places in New Orleans Harbor where such caves occurring would have brought disaster to the city and caused a complete inundation.

Notable instances of subsidences also occurred in the lower part of the city last fall, one of which completely destroyed the levee; fortunately, this occurred at low water in October, thus allowing time for a new levee to be built before the January rise. In view of this fact, it can not be said that under present conditions New Orleans is ever entirely free from danger at flood periods, and, as the levee system continues to be extended along the river, closing one by one the storage basins, the flood heights are steadily growing higher.

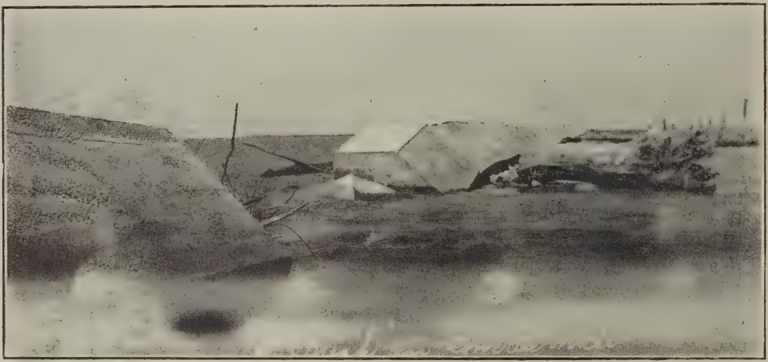


Fig. 19.—Completed jetty, showing break in concrete superstructure due to settlement of base.

A series of waste weir spillways allowing the discharge of the excess waters into the lakes in the vicinity of New Orleans would add largely to the city's security and relieve the port of the necessity of raising the wharf floor lines. A survey for such waste weirs is now in progress under the Mississippi River Commission.

TERMINALS.

The general location of the water terminals is on the city front, and consist of substantial wharves constructed generally of creosoted timber. These wharves are generally covered by steel sheds to protect and store merchandise. The present length of the wharves is 5 miles and the platform area is 2,269,593 square feet. The steel sheds have a total length of 3½ miles and protect an area of 2,600,381 square feet.

During the year ending December 31, 1911, 1,712 ocean-going vessels, aggregating 4,228,238 tons, used the public wharves, and 427 sea-going vessels, aggregating 884,674 tons, used the Stuyvesant Docks of the Illinois Central Railway, and other privately-owned wharves.

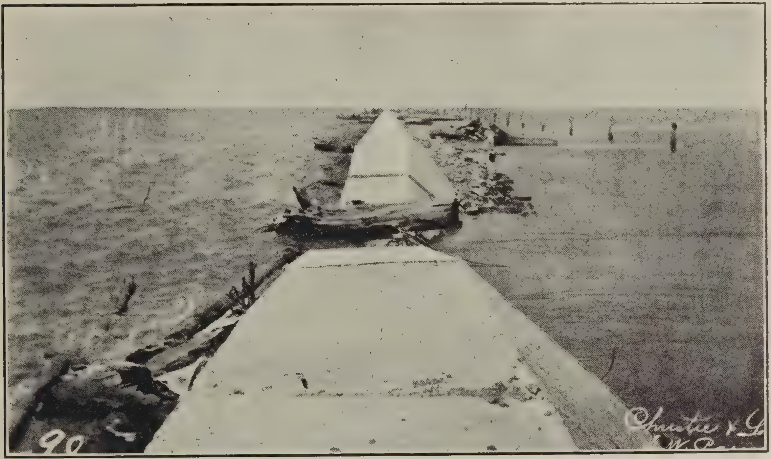


Fig. 20. Another view of break in superstructure, due to settlement of base.

The inland water traffic using the public wharves consisted of 1,497 steamboats, 298 miscellaneous craft, consisting of flats, coal and gravel barges, tugs, transportation barges, etc., and 2,142 gasoline launches and luggers engaged in oyster, fish, and vegetable trade.

The average charge for the use of the publicly owned wharves was $0.0698 per ton. All expenses incident to discharging or receiving freight are paid by the vessel. In the case of regular liners, freight will be received on the wharf in advance of the arrival of the vessel.

In general, the water terminal facilities of New Orleans may be considered as unusually efficient, and they are open to use by all water carriers on equal terms. The publicly owned wharves are operated and maintained by a public board, known as the Board of Commissioners of the Port of New Orleans, and it is the intention to make charges on water carriers merely sufficient to operate and maintain the wharves, sheds, etc. The Illinois Central Railroad and the Texas & Pacific Railway terminals are equipped with elevators and conveyors for the storage and shipment of grain. According to the best information that can be obtained, no charge is made for vessels using the privately owned terminals.

Coordinated with the terminal facilities is the Public Belt Railway, which has 18 miles of main line and 10 miles of switch-tracks extending along practically the entire developed water front of the city. By means of this railway under public ownership and operation, all freight can be transferred from any railroad to any terminal or other industrial connection at a uniform flat rate of $2.00 per car, including the return of the empty. About 150,000 cars per year are handled. New Orleans has been enabled to secure public control of its wharf facilities and belt railway to a greater extent than any other city in the United States, on account of the fortunate servitude resting on all alluvial lands in Louisiana on the Mississippi River, by which they can be taken for the construction of levees whenever required. In the city, a recent constitutional provision allows owners of lands which are taken to be compensated, but outside the city, even at present, no compensation is given for lands taken for levees.

Terminal and transfer facilities provided at New Orleans for ocean steamers and river packets are excellent as to dock space, but can be improved in the matter of storage and handling appliances. At the present time there are no cargo-handling devices in the port owned and operated by the Dock Board, and only the following privately owned: Grain elevators at the Illinois Central Railroad and Texas and Pacific wharves; banana unloaders of the United Fruit Company at the Thalia Street wharf; coffee unloaders owned by W. J. Kearney, Stevedore; barrel and sack conveyors owned and operated by P. J. O'Reilly, Stevedore; general cargo conveyors owned and operated by the Southern Pacific lines. In addition to the above, the American Sugar Refinery has a modern Telpherage system for conveying raw sugars from its wharf to its warehouses at the Chalmette Refinery.

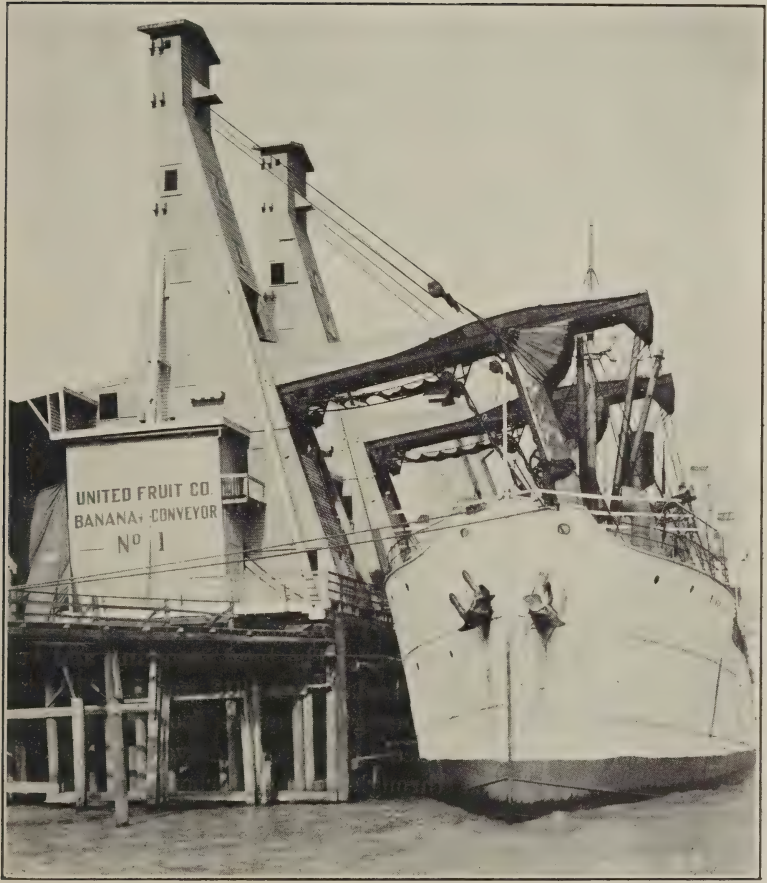

UNITED FRUIT CO.
BANANA CONVEYOR
No 1

Fig. 21. Banana unloader.

UNITED FRUIT COMPANY.

Each of the banana unloaders shown in the illustration herewith, owned and operated by the United Fruit Company, consists essentially of a tower and belt conveyor, to which are attached a series of baskets; they are built by the Harris, Edelston Conveyor Company, New Orleans, La. Each basket carries a bunch of bananas or a sack of coffee. The bananas are placed on the conveyors and removed therefrom by manual labor, being carried at once to the railway cars. There are required to operate the four machines of this company, under full service, about 600 men,including the necessary men in the ships' holds to load the conveyors and the men on the wharf to take the bananas and coffee from the conveyors to the railway cars. The saving secured by the use of these machines in time and labor is about 25 per cent. The value of the four machines is $10,000.00 each, or a total of $40,000.00. Four conveyors are used per vessel, each having a capacity of 2,500 bunches per hour, or a total of 10,000,000 bunches per hour from each vessel. Each conveyor can handle about 1,500 bags per hour, a total of 6,000 bags for the four machines.

SOUTHERN PACIFIC COMPANY.

The Dock Board has allotted to the Southern Pacific Steamship Lines a frontage of 2,100 feet; extending from Dumaine Street to Conti Street, capable of accommodating four 450-foot vessels. Of this frontage, 704 feet is provided with a shed 141 feet wide, and 1,396 feet front has a shed 80 feet wide, making a total of 209,680 square feet allotted to the company. The total incoming and outgoing tonnage handled in the calendar year 1912 was 581,172 tons, or an efficiency of 2.775 tons per gross square foot per year, no deduction being made for offices, conveyors, driveways, etc. If this rate were maintained throughout the harbor, the capacity would be 7,216,557 tons of cargo per year for the port, instead of about 3,000,000 tons actually handled.

Berths Nos. 1, 2, and 3 are each equipped with five electrically driven conveyors or moving platforms, which are approximately 70 feet long, and are driven by 15-horsepower motors at a maximum speed of 225 feet per minute. The out-board ends are supported by steel gallows frames with a lifting and lowering radius of about 25 feet, and requiring to operate them three men each, whose principal function is to prevent accidents and assist trucks from the head of the conveyor. Each of these conveyors has a maximum capacity of 125 tons per hour, but this rate is not possible under working conditions, the average being 125 tons per hour in discharging and loading per ship. The conveyors are permanently installed in the wharf and are built especially to facilitate the discharging of the company's vessels, which are equipped with side ports and are not available for other shippers.

The conveyors are not especially installed to take the place of manual labor, but mainly to expedite the handling of cargo through side ports during normal or low water conditions in the harbor. All of the vessels of this company are provided with side ports, so that it is possible to discharge, without using slings, all the freight loaded in the upper and lower between decks. This aids much in the discharge of vessels, inasmuch as it affords opportunity for discharging cargo at five ports at one time on the inshore side.

The method of operation of the conveyors is for the trucks to go into the ship and be loaded with cargo; at that point the truck with its load is then rolled on to the moving plaform and carried to the wharf end of the elevator.

The possibilities of expedition may be more clearly illustrated by citing the particular case of the Steamship *Antilles,* which was docked at 8.30 a. m., January 25, 1913, and discharged a full cargo of 1,725 tons in 11½ working hours, or an average of 150 tons per hour, employing 355 men. This service included the sorting out and piling on the wharf all ready for delivery to the local consignees, or for loading into cars of connecting lines. This vessel was loaded out with 2,831 tons in 21½ working hours, or an average of 131 tons per hour, employing 200 men. She sailed at 9.15 p. m., January 26, 1913, having spent one day, 12 hours and 45 minutes in port, and having discharged and received during that time 4,156 tons of cargo. On her outbound trip she carried a large quantity of slow-moving freight, such as lumber and timber.

The Southern Pacific Company operates regularly two boats between New Orleans and New York per week, and one between New Orleans and Havana per week, with extra sailing when traffic conditions warrant it; all of these use the conveyors described above.

This company has installed an elaborate system of lighting, so that operation may continue day or night; also canvas flaps or awnings covering the hatches, which enables the work to proceed during rainy weather without damage to cargo.

With these various appliances on the New York and New Orleans line, there are 3,000 pounds of cargo either coming out of these ships or going in for every minute that they spend in port, this lay-time being based on the gross period spent in port with no allowance for time lost in shifting vessels, etc.

The character of freight handled includes every class of merchandise handled in New Orleans on southbound cargoes—consisting of dry goods, boots and shoes, canned goods, and all kinds of manufactured articles, besides cement, roofing, slate, and iron products. On the New York line northbound cargoes consist principally of sugar, molasses, rice, cotton, logs, timber, lumber, box material, barrel material, resin, turpentine and alcohol. The Havana ship line, southbound,carries packing-house products, grain, mill products, box material, crate material, fertilizers and live stock; northbound, sugar, perishables, early vegetables and pineapples.

The average cost per ton for handling for the year ending December 31, 1910, was 54.85 cents per ton of 2,000 pounds, reduced to a basis of 30 cents per hour. Thirty cents per hour is paid for straight labor and 40 cents per hour for night and Sunday labor. In addition to taking twice as long to handle cargo, the cost would be, without the use of conveyors, and operating over-all from hatches with the ships' derricks and manual labor, approximately 25 per cent greater. The above cost per ton appears high, but is due to the amount of light package freight handled. Approximately 75 per cent of the south-bound cargoes are of such miscellaneous light merchandise as dry goods, boots and shoes, notions, hardware, drugs, etc. For instance, the *Antilles,* while she carried only 1,725 tons, was full as far as her cubic capacity was concerned, notwithstanding the fact that she has a gross ton register of 6,878 tons and a net ton register of 4,326 tons; her cargo when discharged covered nearly four acres of floor space. Very few vessels entering the port of New Orleans, except those of the Southern Pacific Company, are equipped with side ports; those having only deck hatches, of necessity, must sling all of their freight over-all discharging from deck hatches to the wharf. The necessity and economy of conveyors for such vessels is not as apparent as for those having side ports.

Ships are discharged to lighters whenever consignees wish deliveries in that manner and conditions are propitious for such unloading. However, less than 5 per cent of the business is handled to or from vessels by lighters, but lighterage is encouraged by the Company.

Texas & Pacific Railway Company.

The Texas & Pacific Railway Company has two grain elevators at its Westwego terminals, with a total storage capacity of 1,350,000 bushels; unloading capacity of 12,500 bushels per hour, and loading capacity of 56,000 bushels per hour. These elevators are equipped with two standard oats clippers; seven separators; one standard Hess corn dryer, with a capacity of drying 1,000 bushels per hour; one Fairbanks automatic grain sacking machine, with a capacity of 540 3-bushel sacks per hour.

In addition to the above elevator facilities, this company has one steam derrick for handling logs from cars to wharf, capacity about 50 tons per hour, and requiring three men to operate. The value of this derrick is $2,000.00, and saves about 50 per cent of the time required for the work by manual labor.

AMERICAN SUGAR REFINERY.

This company operates a wharf 850 feet long in connection with its Chalmette refinery, at which two vessels can discharge simultaneously at all four hatches, and a third at two hatches.

The wharf is connected with the warehouses on shore by approaches, and also by an overhead trolley conveyor, known as the Telpherage System, operated for the exclusive use of the company. There are 25 cars in this system, driven by direct current; each car being operated by one man, and carrying each trip 1 ton of raw sugar from the wharf to storage sheds, a distance varying from 2,000 to 3,000 feet for the round trip. Each car will convey about 15 tons per hour over this distance, 1 ton at each trip.

On account of the considerable distance from the wharf to the storage shed the saving of time by this method over that of any manual labor method of doing this work is incalculable. The appliances are used not only for transporting the sugars for a distance of 1,000 to 1,500 feet, but are also used for tiering up or piling the sugar to any desired height in the shed, and this feature is one of the main advantages of the appliances.

This company does not use mechanical appliances in discharging vessels to wharf or loading vessels from wharf, but this work is done by the regular stevedores, as is the case with other wharves in the port.

W. J. KEARNEY, STEVEDORE.

W. J. Kearney owns and operates a coffee unloader of the Hanak

Conveyor Type. This conveyor consists of a series of independent sections, each approximately 30 feet long, so arranged that any number can be used at will. One section is placed on the deck of the vessel; the derrick raises 10 sacks at a time to a platform on deck, from which 5 men transfer them to this deck section of the conveyor, thence a simple chute carries the sacks down to the wharf section. At the inshore wharf end of the conveyor four men deliver the sacks to laborers carrying them to piles in the shed.

One 5-horsepower motor is used to operate the deck section, and one 5-horsepower motor to operate two 30-foot wharf sections of the unloader. About 1,000 sacks, 130 pounds each, per hour are unloaded by this system as against 500 per hour by derrick and manual labor, at about two-thirds the cost per sack. The greatest saving, however, is in ship dispatch. Using the ship's two derricks, the conveyor will handle about 2,000 sacks per hour, if not delayed by men unloading at the wharf end. It recently required 4½ days to unload 80,000 sacks from the Steamer *Gibraltar,* of the Lambert & Holt Steamship Line. This would have required about 9 days by derrick and manual labor. At a minimum cost of $200 per day this means $1,000.00 dispatch money, to say nothing of the increased resultant capacity of wharf.

P. J. O'Reilly, Stevedore.

P. J. O'Reilly, Stevedore, owns and operates an endless carrier, valued at $25,000.00, open to all shippers for handling barrels and sacks of sugar and barrels of molasses. Its capacity is about 2,000 barrels of sugar, about 1,000 sacks of coffee, or about 1,800 barrels of molasses per hour at a cost of approximately 12 cents per ton. It is estimated that about two-thirds of the time required by manual labor is necessary with this unloader.

COAL HANDLING PLANTS.

There are only three modern coal handling plants in the port (not considering the plant at the Naval Station, now unused) for economical handling of coal from cars to barges, and for bunkering vessels. All of these are owned by private corporations and are not opened to public use at reasonable rates.

Recently it was found almost impossible to have coal unloaded from cars to barges at a fair price, when this coal is bought from independent companies having no interests in these coal facilities. Alabama coal can be bought for $2.45 per ton, f. o. b. cars New

Orleans, and even at 50 cents per ton for placing on barges the prices would be less than can be secured from the other companies here, but it was found impossible to get the coal transferred from cars to barges.

SWITCHAGE FACILITIES.

There are only two cases where railroad cars can be placed alongside the vessels, with a total of 1,600 feet of track. Of the above, the New Orleans & Northeastern Railroad has four tracks on its wharf, covering 1,000 feet, the nearest of which is 8 feet from the ship's side. The absence of adequate switches lying alongside the wharf front places a burden on all traffic in the haulage required from the Belt Line Switch to shed floor or ship's side. Shipments are further burdened with the handling or haulage charges incidental to the movement from sheds to ship's side by manual labor. Telpherage Systems now extensively used at the more advanced ports have not been introduced, except on a small scale by individual corporations, but the Dock Board has now under contract three banana unloaders for public use.

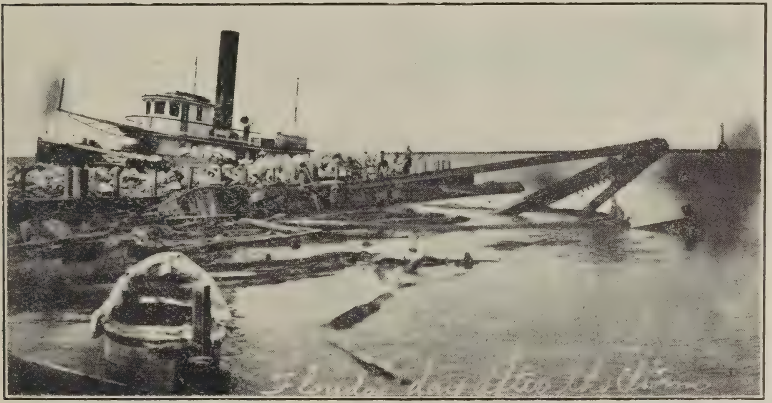


Fig. 22. Derrick barge wrecked during storm.

By the installation of suitable switches along the ship's side with movable cranes operating over them, and Telpherage Systems in the sheds in co-ordination with the present excellent Public Belt System, which lies in the rear along practically the entire developed water front, a large saving in handling charges would be effected. A considerable percentage of the bulk freight could be placed directly from the ship to flat cars by one operation of crane as against the present three or more operations.

SHEDS.

The sheds up to this time built are used both as storage and transit sheds, but they are becoming rapidly necessary for transit freight alone, so that they should be supplemented in the near future by warehouses for the storage of freight while being accumulated and awaiting shipment. This is contemplated under a recent constitutional amendment by the State of Louisiana, authorizing the New Orleans Dock Board to install and operate a system of warehouses.

There is also a deficiency in the present system, due to a lack of space for incoming and outgoing cargo. This could be obviated by having two floors, one for incoming, the other for outgoing freight, so that loading and unloading could be carried on to some extent simultaneously. This system is being inaugurated in the most advanced European ports.

The shippers also complain that many of the sheds are too narrow to accumulate an average ship load of freight at one wharf. The sheds should be from 250 to 300 feet wide, in order to hold about two-thirds of a cargo of cotton at a single berth, thus requiring only one-third of the cargo to be hauled to the berth during the time of loading. In unloading cargo from ship to car at some of the wharves, it is necessary to cross streets congested with traffic to reach cars; to avoid this delay it would be well to have tracks in all cases along the land side of the wharf with driveways down the center of the sheds.

The present sheds are of steel construction as to superstructure, and the fire hazard is reduced somewhat on account of this steel construction; but since the floors and foundations are all of timber there is still a large degree of fire hazard in storage of perishable cargo, especially cotton.

LIGHTERAGE.

The maximum rate of unloading and discharging vessels is not secured for the further reason that no public lighterage system has been inaugurated. Such a system is essential to the economical operation of vessels, especially those of large tonnage, on account of the resultant decrease in time lost in taking on and discharging cargo when done simultaneously on both sides of the ship. Barges are also valuable in collecting miscellaneous freight from various warehouses or sheds without necessitating the shifting of the steamers to the different docks. Bulk cargo in flat cars could thus be economically hauled to the ship's side, and there unloaded from car to vessel in one operation. The steamship people maintain that this charge should be absorbed by the railway company, as it is done at some of the eastern ports where shifting the vessels is not practicable.

HARBOR LINES.

The city of New Orleans has already developed its terminal facilities to a point equal to that of any other large American city, but the ultimate results can not be secured until the banks of the Mississippi River throughout the harbor are thoroughly fixed by bank protection. This work has been carried forward from year to year, until now 47,170 feet out of 174,668 feet (on both sides) have been protected. As a large part of the river bank is not caving, there remains to be protected to give stable banks about 18,500 feet. As soon as the banks are fixed in position, harbor lines should be established to insure a proper development of the pier head line, part of which is now out of line.

In a part of New Orleans Harbor at the present time, due somewhat to the fact that the caving banks have not been protected, there is a considerable shoaling which intereferes with the prompt berthing of large vessels. This is notably the case at Stuyvesant Docks, where the Dock Board maintains a dredge during low water to keep a sufficient depth of water in front of the wharves.

"Men of strong individuality are with us, unfortunately, often passed over instead of receiving accelerated promotion. Because they are a source of anxiety to some officers in peace time, they get suppressed as being headstrong. The result is that they leave the service; whilst others who possess neither force of character nor conviction, but who are subservient and always ready to agree with their superiors, are promoted."—*From Kuropatkin's Farewell Memorandum to the Russian Army in Manchuria.*

An Open Letter on Night Fighting and Outposts*

You ask me to tell you something about night fighting, so I propose in this letter to give you my views on the subject for what they are worth. Probably it would be best not to enter into the question of large night operations, but to confine ourselves to discussing quite small affairs, with the object of learning something that will be useful to regimental officers.

It is generally accepted that night operations will frequently be resorted to in the future. Perhaps, however, there is a danger that soldiers who have no actual experience may enter into this extremely risky class of fighting without fully realizing what they are committing themselves to. There is nothing so upsetting to the nerves as the unexpected—and therein lies the danger of the valor of ignorance; not that there is anything extraordinary about night fighting, it is very much what a man of ordinary intelligence and imagination might expect. Nevertheless, the first actual experience always seems to give men an unpleasant surprise.

The general impression left on the mind is one of utter confusion. Each individual knows only what is happening in his immediate neighborhood, and he is in complete ignorance as to the fortunes of his comrades, and of the success or failure of the plan as a whole. The scheme which, beforehand, seemed so clear and well thought out to the minutest details, seems suddenly dependent on numberless chances impossible to have been foreseen or provided against. If the night is dark there is an uncomfortable feeling that we may fire into our own friends, or what is just as bad—or even worse—that they may be firing at us. Even when it comes to close bayonet fighting it is difficult to tell friend from foe, unless there is some distinctive dress. Severe night fighting is not a pleasant business, and probably no man can truthfully say that he has enjoyed the experience. Although a knowledge of what to expect will not exactly make you joyful, it will be useful, provided you can apply your knowledge. Many of the risks can be minimized by a little forethought. Above all, realize the

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*This letter, which is from a friend who combines in himself brains and experience of war, having come into my hands, I have asked the Editor to find room for it in an early number of the *Journal*. It merits careful perusal and consideration by all ranks.—L. A. H.

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fact that complicated plans and intricate formations are a certain source of disaster, and should, therefore, be avoided, while all ranks should understand that success greatly depends on offensive action backed up by real fierceness in the fighting.

It requires no genius to grasp the fact that peace training, no matter how good it may be, can never reproduce anything like the scene that must inevitably take place when a night collision occurs in actual warfare. Because a certain maneuver or formation appears to be successful against a flagged enemy, or against troops who have only blank ammunition and do not use the bayonet, it does not in the least follow that similar methods would not lead to disaster against a real enemy. Probably an attack like Magersfontein would be a glorious success in peace. So, whatever you do, always remember that the peace picture is only true to war up to the point when the first shot is fired.

I don't think I can do better than tell you the story of an actual experience, and on that story try to base some principles which you may perhaps find useful to you in the future.

The siege of Ladysmith commenced about November 1, 1899. Early in December Sir George White knew that General Buller was about to advance to the relief of the garrison. General Buller had informed Sir G. White that the Boer position on the Tugela would be attacked on December 17. How far this information influenced Sir G. White in deciding to make night sorties from Ladysmith, I do not know; but it is probable that he argued that it was imperative for the garrison to rouse itself and do its best to draw as many Boers as possible from General Buller's front. Such reasoning seems to be only common sense. Whether Sir G. White meant to carry the argument further, and make a resolute attack at the same time as General Buller, is not common knowledge, and moreover, that is another story and has nothing to do with my letter. In any case General Buller took the matter out of Sir G. White's hand by attacking on the 15th instead of on the 17th.

On the night of December 7-8, General Hunter took out some 600 Imperial Light Horse and Natal Carabiniers and blew up two big guns (a "Long Tom" and a 4.7-inch howitzer), besides capturing and bringing in a Maxim. The Boers made no stand at all; the only casualty on our side was one officer wounded. Everything went well; the Boers were so badly surprised that there was practically no night fighting; and as it is on that subject I am more particularly writing, there is no use in our going into the details of the sortie. We can, however, see the truth of the principles which lay stress on the value of the offensive spirit, the enormous advantage which is gained by surprising one's enemy, and the importance of careful and accurate night guiding. There can be no doubt that General Hunter's sortie did more to increase the fighting spirit of the garrison (in other words, its *morale*) than anything that had taken place since the commencement of the siege—this alone was a matter of supreme importance.

The success of the sortie was so startling that it has been suggested we ought to have made several simultaneous sorties, thus taking advantage of the fact that the Boers did not keep strong posts round their guns at night. But we must not forget that Sir G. White could not have known this, and the responsibility was his. Also, there were some practical difficulties which are sometimes overlooked—for instance, how could the attacks have been timed to take place simultaneously? The chances are that one column would have struck the enemy's pickets unexpectedly, firing would have begun, and the whole Boer line would have been on the *qui vive.* It would have been exceedingly difficult to bring off several attacks successfully, and it would have been leaving too much to luck—a fickle goddess and one not to be depended upon in war.

Encouraged by General Hunter's success, the question of another effort was mooted. The chances were that the enemy would have strengthened their posts, but on the other hand, it was just possible that another sortie would not be expected so soon. The question was which gun to select. As far as the northern front was concerned there appeared to be three possible objectives:

The big gun on Telegraph Hill;
The 12-pounder high-velocity gun on Thornhills Kopje;
The 4.7-inch howitzer on Surprise Hill.

The Telegraph gun, for some reason (probably difficulty of ammunition supply), did not shoot much, and the garrison felt no particular animosity against it. Also, there was a searchlight fixed up close to the gun, which might have made a night surprise difficult and, as can be seen from the sketch map, there was a stream to be crossed; also, it was thought that the Boers would have pickets at the drifts. The distance also was great, and if any hitch had occurred a retirement would have been difficult—to say the least of it. *The Thornhill gun* was close, only 2,500 yards away from our lines. It was thought, however, that the Boers would be expecting us here, and as it was a rough stony hill, troops advancing over it in the dark would be certain to make an abominable noise.

There remained *the Surprise Hill howitzer.* This gun had made itself rather a nuisance, and being a howitzer, its shells used to drop over the trenches at an unpleasant angle. The hill itself had what appeared to be a grassy slope, with some scrub and low trees. There were some rough looking rocks here and there. It was so far back that the chances were that the enemy would think it safe from attack. It was about 4,500 yards (say, 2½ miles) from Kings Post, and to get at it an attacking column had to pass through a sort of tunnel—that is, between Thornhills and Bells kopjes (1,500 yards). After passing between these two hills the so-called "tunnel" ran for 2,200 yards and ended at Surprise Hill. One advantage about this was that it simplified the question of guiding, as, to people in the valley, Surprise Hill stood out boldly against the sky line. The name of the hill was a good omen.

On considering the advantages and disadvantages of the three possible objectives, it was thought that Surprise Hill offered the best chance of success, principally because we were more likely to surprise the Boers there than anywhere else.

Before definitely deciding on making the sortie Sir George White sanctioned a reconnaissance being made, and requested that a plan should be submitted. On the night of December 9 accordingly, a party, consisting of four officers, one sergeant, and six company scouts, went out. The main object of the reconnaissance was to discover whether the Boers kept any pickets on the railway line. No pickets were found. The wire fences alongside the line were not cut, as it was thought that if it was noticed the Boers might suspect our design. Perhaps the reconnaissance might have been pushed further, but it must be remembered that if the enemy's pickets had been run into, the chances were it would have made the Boers particularly watchful for some nights.

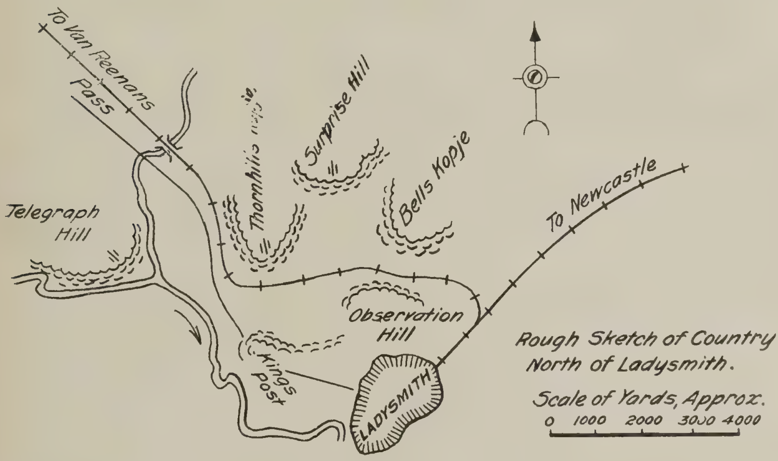
To Van Reenans Pass
Telegraph Hill
Thornhill's Kopje
Surprise Hill
Bells Kopje
To Newcastle
Observation Hill
Kings Post
LADYSMITH
Rough Sketch of Country North of Ladysmith.
Scale of Yards, Approx.
0 1000 2000 3000 4000

Fig. 1.

It should be mentioned that during the afternoon, till it was too dark to see, Surprise Hill was closely watched through a powerful telescope, so as to try to locate the pickets and night dispositions. As far as could be seen there were only about twenty men around the gun. Men could be observed walking about, shaking out their blankets, and making themselves comfortable for the night. The fact that men walked freely about the top of the hill and down the slopes made it fairly obvious that there were no barbed wire entanglements to be feared. At daylight the next morning, the 10th, the telescope was brought into requisition again. Undoubtedly, valuable information was thus gained easily and without arousing the enemy's suspicions.

The morning of the 10th was spent in making out the plan. Only five officers (excluding Sir George White and some of his staff) knew anything about it—the general commanding the brigade (Sir F. Howard), the colonel commanding the battalion, and the officers who had made the reconnaissance. The escort which accompanied the reconnaissance the previous night had been told a lie, and apparently believed it. After much discussion the following plan was decided upon:

The sketch shows the formation for the advance and the method of deployment.

Five companies were considered sufficient, with a small party of artillery and engineers (one officer and four or five men each). The column was to deploy at the foot of the hill (see sketch below). A Company, with two sections of H in single rank, were to advance straight on the gun and proceed 100 yards or so beyond, and there form a rough crescent covering the gun; the remainder of H Company, with the engineers and artillery, were to follow closely behind, and to them was delegated the actual work of blowing up the gun. B and G Companies were to proceed nearly up to the crest of the hill and face outwards, with the object of dealing with any Boer counter-attack, and also to give the leading companies a line through which to pass on retiring. There remains E Company; half of this company was to be left behind at the railway to prevent the Boers blocking the retirement; the other half was to accompany the column to the donga at the foot of the hill,* also with the object of preventing the Boers blocking the retirement.

This plan was submitted to Sir George White, who approved of it, and it was settled that the attack should be carried out that night—that is, the night of December 10-11.

The hour of the attack was more or less fixed by the following conditions:

1. The 10th was a Sunday, and as the Boers made a practice of not shooting on the Sabbath, a custom much appreciated by the garrison, it was decided not to make the attack till after midnight in order not to establish a precedent.

2. The moon did not set till about 11 p. m., therefore the attack had to be made after that hour.

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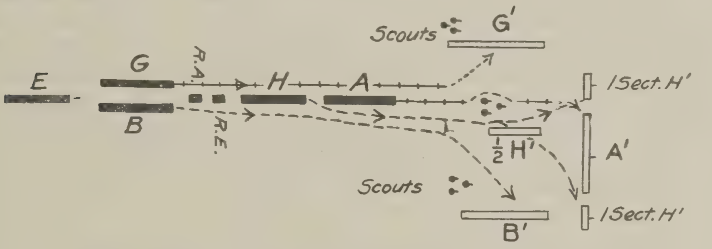
*It was thought at the time that there was only one donga at the foot of Surprise Hill. Through a telescope it looked as though this was the case, and a local man confirmed the idea. As a matter of fact, there were two other small dongas. As will be seen, this mistake led to trouble, and it affords us a good example of the possible consequences of bad information.

3. It was, of course, imperative that the column should be back inside our own lines before daylight, and therefore the attack could not be made much later than midnight.

In order to facilitate the retirement it was arranged that three lamps should be hoisted on Kings Post shortly after midnight, the object being to give everyone a line to retire by.

It should be mentioned that Sir George White gave instructions that the attack was only to be made if a surprise could be effected. Personally, I think this was a sound decision, as it would have been a bad business, both actually, and for the *morale* of the garrison, if the attack had met with a bloody repulse. For a particular jaunt of this sort, it was not at all a bad thing to leave this discretion to the commander of the column; but if the attack had formed part of larger operations, or the capture of the hill had been essential for other reasons, it certainly would not have been advisable to issue such instructions. Under these circumstances the supreme commander should take the responsibility on his shoulders and give definite orders.



Key: *ABGHE formation previous to deployment, companies in fours.*
A'B'G'H' formation after deployment.
There were no scouts ahead of the front line.

Fig. 2.

There was some little difficulty about obtaining guides. Luckily, Mr. Thornhill, the owner of the farm at Thornhills Kopje, was available, and another local man named Ashby. These two reported themselves at battalion headquarters during the afternoon, and it was then explained to them what was required of them. One can not help wondering what the feelings of some of our English country gentlemen would be if they were suddenly called upon for a job of this sort.

About 7 p. m., the colonel explained the plan to the officers. He did so very fully, and everyone asked questions until the colonel was satisfied that the whole scheme was thoroughly understood by all. The company officers then went to their companies and explained the whole plan to the non-commissioned officers and men. You may be sure that seldom have officers had a more attentive audience. Remember, if it ever falls to your lot to take part in an affair of this sort, that these explanations are most important; in fact, they are essential to success.

Of course, it was necessary to warn the troops holding Observation Hill that a sortie was going to be made. I am not quite sure of the exact time they were informed, but probably not before 7 or 8 p. m. It was obviously necessary to do this, as otherwise they might have fired on the column, either as it was going out or returning.

The column fell in at 9.30 p. m. and moved off, led by the two guides and the officers who had made the reconnaissance the previous night. The moon happened to be more than usually bright, so the column halted before reaching the railway and waited for an hour or so. The railway line was the first obstacle to be crossed; it was thought that the wires might make a noise when being cut, especially if they were tightly stretched, but there was no bother at all. Two men held the wire and then it was cut between them and allowed to slacken quietly. I forgot to mention that the Boer searchlight on Telegraph Hill had been switching about. It looked rather alarming, but there was really no difficulty in dodging it by lying down whenever the ray of light approached the column. The grass must have been 9 to 12 inches high, and it is a well-known fact that stationary troops are difficult to pick up with a searchlight.

Half of E Company was left at the railway as previously arranged.

The column now advanced into the tunnel. Bells Kopje on the right and Thornhills on the left stood out rather threateningly, while Surprise Hill frowned up clearly against the sky-line in front—there was no question of losing sight of the objective. As the column slowly advanced and left Bells and Thornhills kopjes farther and farther behind the situation did not look too pleasant—in all probability the thought uppermost in most men's minds was: "I hope there will be no trouble in getting back." Mind you, everybody knew the Boers were in occupation of these hills.

The night had now become very dark. Just as the foot of the hill was reached and the bushes and longer grass round the nullah could be seen by the leading men, a light was apparently struck about 20 or 30 yards ahead. It was a moment of great suspense, but nothing happened—there was just the flash of light and then darkness. The scouts, who at this time were about 20 or 30 yards ahead, went on and found nothing. What would have happened if even twenty resolute Boers had suddenly opened fire with magazine rifles? All question of surpise would have been over, and the first blast of fire might well have knocked over most of the leading men. One has to have been faced with a situation such as this to realize that it is no easy matter to charge—still the fact remains that a *prompt and resolute* charge is the best way out of the trouble. If you have good reliable men you may possibly meet the situation by returning the fire *at once* (but this means having some men with their rifles ready for immediate use), and after one rapid burst of fire closing with the enemy. What I want to impress upon you is that it is one thing to talk about charging,and quite another thing to do it; also bear in mind that everyone must know what to do—it should be explained to the men before starting—there must be no waiting for orders, for who knows but that the man whose order you are waiting will not be lying dead with a bullet through his brain.

From the accounts afterwards given by the Boers themselves, it appears that there was a picket at the bottom of the hill. These men all of a sudden became aware that British soldiers were on the top of them; they were face to face with a somewhat serious crisis—if they fired they would disclose their presence and would probably be killed by the crowd of men they saw looming in the darkness; if they lay still all might be well as far as their own skins were concerned. Whether they thought of their duty to delay the attacking column and warn their friends in rear—who knows? They lay quiet. One of the Boers afterwards said that a British soldier put his heavy ammunition boot on his hand.

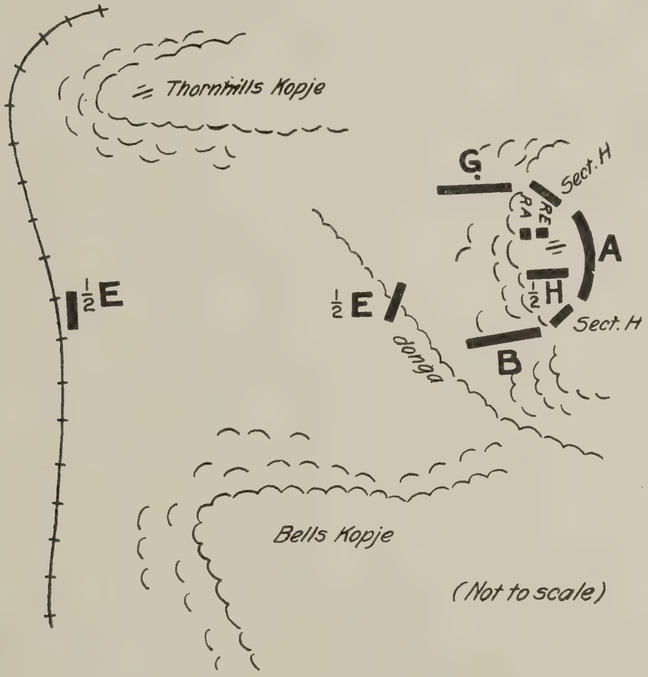


Fig. 3.

To return to the column. The advance was continued, and the incident of the lighted match was finished as far as they were concerned. The remaining half of E Company halted in the donga. Two more small dongas were crossed and the slope of the hill reached—it seemed but a short distance to the top of the hill.

The colonel now decided to deploy; this was carried out without a hitch and wonderfully silently. The leading company just filed to the right and halted in single rank facing the hill; swords were fixed, and nothing remained to be done except to wait for the order to advance. I forgot to tell you that before starting the magazines were charged, but the chambers were empty. Strict orders had been given that as soon as the enemy opened fire the leading troops were to advance with the bayonet, and there was to be no firing at first.

When the colonel was satisfied that everything was ready he passed the word to advance. Quietly and slowly the men moved forward, stepping delicately like Agag. The tension was acute; quite instinctively the pace increased; the ammunition boots seemed to make noise enough to be heard miles away, but still no sign of an enemy—the hill seemed to go up and up, and to be a longer climb than was expected. By this time the troops were nearly on the top of the hill, and, as you can imagine, everyone realized that something must happen soon. Suddenly a voice was heard about 10 yards ahead of the line saying ''Wer da?'' Probably everyone gave a sigh of relief—something had happened at last. No answer was given to the challenge, but the advance continued. There was a flash and a shot—where that bullet went no one knows. The Colonel (who had a powerful voice) yelled ''Fix bayonets''*—this with the idea of upsetting the nerves of the Boers, who, at that time—quite erroneously, I think—were supposed not to be able to stand up to cold steel. The order was taken up by the officers and non-commissioned officers, but as a matter of fact the swords had already been fixed, so there was no delay. The officers gave the order to charge, and the front line broke into a run, cheering as they advanced. We ought to teach our men to cheer—it is really important—a good hearty, fierce yell is very upsetting to the nerves; the British cheer in the Peninsular War is famous, and no one can read about the American Civil War without finding frequent reference to the Rebel yell. There is something about the human voice raised in anger which is apt to put the finishing touch to a man whose heart is not quite in the right place. Of course, indiscriminate cheering should be checked—it is frequently a sign of nerves—the real cheer should be reserved for the moment when the hand-to-hand conflict is about to take place.

Undoubtedly, the Boers were absolutely and completely surprised; the only man who put up any effort was the sentry—every other Boer on the hill was out of his blankets and away. The celerity with which they made themselves scarce was astounding. A and the two sections of H Company had no difficulty in taking up their allotted stations, thanks to the careful explanations given beforehand. The remainder of H Company, and the artillery and engineer detachments had some little difficulty in finding the gun, which had been withdrawn a little way from the gun sangar. Eventually, the fuse was set, and everyone waited for the explosion. It must be understood that all this took about a quarter of an hour or twenty minutes. Up to this not much firing had taken place on the top of the hill. Gradually, however, snipers began to collect, and a dropping fire commenced. At night, of course, a man firing gives his position away by the flash of his rifle, and it was found that the Boer fire could be kept under control by adopting the following method: Say the flashes came from a certain direction, five or six men would be told to fire; then, after an interval of twenty seconds or so, by which time the enemy, it was hoped, had put their heads up again, another party was told to fire. This plan appeared very successful. Although there were a certain number of bullets humming about there were only three or four casualties; but even these were a bother, as, naturally, it was desired to get the wounded back to our own lines. Carrying a wounded man down a rough hill side in the dark is not an easy business, and, what is more particularly to be noted, it takes men away from the firing line. Under the circumstances, it was a mistake to try to get away any except those who could walk.

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*The regiment happened to be a rifle regiment, and, consequently, the order ought to have been ''Fix swords,'' but it was thought that the Boers might be more impressed by the better-known word ''bayonet.''

Another small point to note is that bullets hitting among rocks make a flash and a smack very similar to a shot being fired, and consequently there is always a danger of the men thinking they are being fired into by their own friends—an uncommonly unpleasant experience, and more apt than anything else to upset men's nerves.

Everyone was waiting for the explosion, but none came—at first it was thought the fuse was burning more slowly than was expected, but gradually it became apparent that something had gone wrong. It is a ticklish business approaching a fuse with a charge of guncotton attached to it, but time was precious, so after a reasonable pause, the fuse was examined. It was found that the fuse had failed, and the charge was prepared again. This time all went well. The explosion was greeted with cheers, as all this unexpected delay was trying to the nerves. In making the plan many things had been considered, but no one had anticipated a contretemps with the fuse. As things turned out the delay cost a good few lives.

As soon as the gun had been blown up the colonel sent word to the advanced troops to retire. This was carried out section by section, the subalterns taking charge of their half companies. The Boers on the top of the hill continued sniping, but made no serious effort to close. Everything looked rosy, and, probably, everyone breathed a sigh of relief and thought that the serious part of the business was finished. The story from now on is not easy to follow; it must be remembered that it was very dark and it was impossible to see a man 3 or 4 yards away unless he stood up against the sky line.

It will be remembered that B and G companies were on the slope of the hill facing outwards; the distance between them was probably about 150 yards—but 150 yards on a dark night and over rough country is a long way. An officer started to walk across from one company to the other, but after proceeding some way he realized that it would be a very easy matter to lose his way in the dark, so he returned. We are always being told that intercommunication is most important, and here is a case in point. Apparently, there was no communication between the colonel and the officers commanding B and G companies. Mind you, the plan had been most carefully thought out, and, it was believed, every possible contingency had been considered; but it shows how difficult it is to think of everything, and this matter of communications was perhaps rather overlooked. Do not imagine, however, that it would have been easy to arrange. Ask yourself the question and think how you would do it—you wont find a solution staring you in the face. What do you think of the following suggestion (see sketch)?

B and G companies to be brought up close to the top of the hill, so as to be in actual touch with the assaulting companies, with a company officer on the flank of B and G companies in order to keep in touch with the colonel.

What happened was this: the men on the top of the hill received the order to retire, and started coming back; but B and G companies did not know when the retirement had commenced. All they knew was that dim forms could be seen coming down, but how were they to know when all the men had passed? This difficulty had not been foreseen. The result was that no one quite knows the order in which the companies came down the hill. Suddenly, without any warning, heavy rifle fire commenced from one of the dongas between the top of the hill and the donga where half E Company had been left. What with the flashes and the reports of the rifles, and the flashes and the reports of the bullets smacking up against the rocks, it was almost impossible to make out what was going on. The air seemed to be filled with the swish, swish, of bullets. To add to the confusion the Boers from Thornhills Kopje fired two or three shells, which, however, burst too high to do any damage; a pom-pom from Bells Kopje joined in, and the Boers from the top of the hill also commenced shooting "into the brown" below. If you have any imagination you can picture the scene for yourself. Remember that it was very dark; it was impossible to tell friend from foe, and, naturally enough, the first impression was that the companies in the rear had opened fire on the returning companies.

Such is night fighting.

Anything in the shape of superior command is out of the question; any control exercised by the commander can only be by means of explanations and instructions given before starting to the attack. Remember this, and do not think you are wasting time by explaining the plan to *all ranks;* remember this, and do not be led into making complicated plans, even though they may appear all right on paper.

In this particular case, everyone knew what to do—that is, to continue firmly down the hill, using the bayonet. Some of the men started to climb up again, with the idea of attacking the Boers, who were shooting from the top of the hill, but they were stopped by their officers—if they had been allowed to do so they would have been wiped out as soon as it became light. The men faced the situation as British soldiers have so often done before. Owing to the darkness and confusion, the company commanders could not actually take personal command of their companies; they had to do the best they could through their subalterns. The different sections were, however, able to keep more or less together. Thus, gradually, but still steadily, and with wonderful discipline, the companies forced their way down the hill. The actual details of how that descent was made can never be told as a consecutive story; even those who took part in it have but a hazy impression of passing through a storm of bullets, of sudden outburst of shots, almost in their faces, when there was nothing to be done but to go straight in with the bayonet.

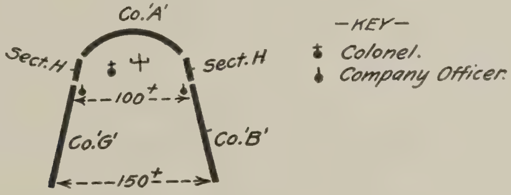

Fig. 4.

On arriving at the more open ground at the foot of the slope further opposition ceased, and the rest of the way to the railway was accomplished without any difficulty. By this time it was getting rapidly light, and when the railway was reached it was possible to see two or three hundred yards ahead—a little later and the men would have been exposed to view and fire from Bells and Thornhills kopjes.

The casualties were not as severe as might have been expected: Killed, 12 (1 officer); wounded, 40 (3 officers); missing, 6 (stretcher bearers); total, 58.

The strength of the column was 448 all told, including E Company. It says much for the behavior of British troops that there were so few missing. The Boer losses were approximately the same as ours.

As far as the story goes, this is all there is to tell; but it is of no use to take part in, or study fighting unless we *think* over the matter afterwards, and try to extract something that will be of use to us in the future. I propose, therefore, to give below what appear to be the lessons, and you can think them over and form your own opinion.

LESSONS.

1. *The Importance of Previous Reconnaissance.* But do not overlook the fact that much can be done with the aid of the telescope, and remember that if you reconnoiter too obviously there is danger of arousing the enemy's suspicions and putting them on their guard.

2. *The Importance of Previous Explanation to all Ranks.* If the story I have tried to tell has not made it clear to you that it is next to impossible to exercise command once troops become engaged in the dark—then I have failed in one of the main objects of this letter.

3. *The Importance of a True Understanding of What Night Fighting is Like.* Without this knowledge there is a risk of launching out into night attacks in too light-hearted a spirit; also, we are liable to make unsuitable dispositions (both for attack and defence). The knowledge of what to expect is also of great value in enabling an officer to keep his head when the crisis arises.

4. *Simple Formations and Few Detachments.* The confusion that takes place in a night fight is very great. You should do everything in your power to minimize this; a simple plan and simple formations are far less likely to miscarry than complicated ones. Once firing commences in the dark, the best of troops are liable to shoot into their friends; this is more particularly the case if troops are on the move, and it is for this reason that detachments should be reduced to a minimum.

5. *Do Not Expect Your Plan to Work Out Like Clock-work.* Try to be prepared for everything. Think out what you will do under every imaginable circumstance. Something unexpected is almost certain to turn up.

6. *The Enormous Value of Surprise.* A point to remember is that we must not rest satisfied with surprising the enemy's troops (his pickets, sentries, etc.); we should also try to surprise the enemy's commander by attacking at unexpected places or times. Whether we can surprise the enemy's troops depends upon the precautions he has taken, and the vigilance of his men—matters over which we have no control; but if we can take the enemy's commander unawares, we may be able to crush his troops by sheer weight, no matter how vigilant they are.

7. *Importance of Having Sufficient Troops Immediately Available to Defend Localities Liable to a Sudden Attack.* The folly of the Boers leaving so few men to defend their gun was beyond words,

especially when we remember their experience at Gun Hill, only two days previously; but probably they thought Surprise Hill was an unlikely objective. Remember that it takes time to bring troops up at night, and that, owing to the confusion and darkness, it is extremely difficult to give support to troops who are closely engaged; it is no easy matter to distinguish friend from foe, and you dare not shoot for fear of firing into your own people. You should also bear in mind the fact that reserves moving up to support troops who are closely engaged are almost bound to come into a bullet-swept zone some distance in rear of the actual scene of the conflict. Bullets may even be coming so thick as to make it almost impossible to advance. Troops under these circumstances frequently imagine that they are being shot into by their own people, or that they have only the enemy in front of them. Be prepared for this, and if you are in command of the supporting force, make up your mind how you are going to act.

8. *Value of Counter-Attacks.* Although the effect of a counter-attack in the dark may be even greater and more rapid than in the daylight, still it requires determination of a high class to make a counter-attack at night. All fighting involves the taking of risks, but this is more particularly the case at night, when, undoubtedly, success or failure is more dependent upon fortuitous circumstances than in any other class of fighting. It is this uncertainty which is so apt to deter a commander from taking action. At the same time, we must train our minds to see the matter from an enemy's point of view, and as soon as we do this, it becomes obvious that nothing can be more dangerous than to allow the enemy's plans to work out undisturbed. Naturally, if everything is going so well that it is clear we can repulse an attack without the risk involved in a counter-attack, it may be advisable to sit tight, on the principle that a bird in the hand is worth two in the bush. But if things are looking black, remember that you have a strong card in a counter-attack, which may alter the whole situation. This knowledge may assist you to harden your heart to take the bold, but correct, course.

9. *Value of the Company System.* It is to be regretted that the company system is so little understood in our Army. Our Field Service Regulations certainly lay great stress on it, but the fact remains that the system is not carried out in many of our battalions. No doubt there are great difficulties to be overcome in peace, such as the weakness of the companies serving at home, the number of courses, fatigues, and extra-regimentally employed men, the number of recruits who have not done their musketry or gymnastic courses. But these obstacles can be overcome to a greater extent than is often realized. You may be certain that when war comes a regiment which has been trained on the company system will give a better account of itself than one which has been trained under a more centralized system. For peace purposes, and even for ma-

neuvers, the company system is not required; its value is only realized in war. How often does one hear infantry officers speaking with envy of the system in the artillery, where a subaltern is given command of his section of two guns from the day he joins? There is no reason why an infantry subaltern should not be given his half-company in exactly the same way. How often do we see infantry officers moved from company to company, simply and solely to give them temporary command? Under the company system subalterns remain permanently with their half-companies; if the captain is away the senior subaltern of that company is invariably given command—even if he has only six months' service, and there is a subaltern of twelve years' service in another company. How can we possibly hope to train officers to take responsibility, except by giving it to them from the day they join? In peace, soldiering can to a great extent be cut and dried, and if it is so desired, we can produce a machine which works ''by order.'' The truth is, it is easier in peace for a colonel to rely on his adjutant and regimental staff than it is for him to work through his company commanders. In the same way, it is easier for a captain to run his company and to ignore his subalterns—in fact, he often does so under a mistaken sense of keenness. The subaltern also can ignore his section commanders. In peace the evils of such a system are not obvious, but in war the centralized method is altogether unworkable.

I am afraid that you may think that I have forgotten that I am writing to you about night fighting, but such is not the case. I have tried to make it clear to you that in the hurly-burly of a night fight even a captain can hardly control his company, he has to do so through his subalterns. A command of about 100 men is the absolute maximum that one man can manage, and this is a matter which ought to be very seriously considered before we change our battalion organization from companies to double companies. A double company commander could not possibly control such a large command in a night fight; he would not even be able to do so through his four subalterns, for the simple reason that it is hard enough to keep touch with the two subalterns in a small company, and he would never be able to do so with the four in a double company. It will be worth your while to consider the story of Surprise Hill. Imagine that the battalion was organized in double companies, and try to think what a double company commander's position would have been during that night's work.

10. *The Importance of Inculcating a Fierce Fighting Spirit.* It may be thought that this is not an easy thing to do, and that it is a question of the individual temperament of the man; personally, however, I am inclined to think that something can be done by constantly laying stress on the value of fierceness when it comes to hand-to-hand fighting. After all is said and done, it is this savage instinct which makes certain soldiers terrible in battle. The ''per-

fect gentle knight,'' whom we read about and admired in the days of our childhood, was capable of being roused, and when he did fight he meant business. When we are teaching our men to go in with dash and resolution, we might put the matter before them in more homely language, and call it fierceness, and explain to the men that they must kill their enemy, and, what is more, they must be quick about it.

11. *The Value of Discipline.* It seems almost unnecessary to lay stress on such a self-evident fact; but, all the same, do not overlook it. Discipline is put to a high test in night fighting, without it the men will lie down or otherwise seek cover. In the particular case we have been discussing, an undisciplined regiment would have got into bad trouble.

The above appear to be the main lessons that we can learn from the Surprise Hill affair. Before I close this letter there are a few general principles that are perhaps worth mentioning.

MOUNTED MEN.

Remember that mounted men can not put up much of a fight at night; to do any good they have to get off their horses and fight on foot. This means that it is seldom advisable to put mounted men at the head of a column if the enemy is likely to be encountered in the dark. Even mounted scouts are of doubtful value, especially if you are operating in a close country. Of course, this does not mean that the cavalry can not move about at night; but bear in mind that if a mounted column is suddenly fired into at night the result may be extremely serious. Extra special precautions should be taken to ensure the marching column from sudden attacks—the closer the country the greater should be the precautions.

NIGHT OUTPOSTS.

Just a few words on the subject of night outposts. Pages could be written about this, but I only propose to call your attention to some questions which you certainly ought to consider closely.

Outpost Companies. As you know, our system is to work by ''outpost companies''—the idea being that the pickets and supports are found by the same units. The principle is quite sound, provided it is intelligently applied. Every outpost problem must be approached on its merits, and we should not adhere blindly to our system if the situation requires that it should be modified. The strength of the outposts naturally depends on the size of the force to be covered, the likelihood of attack, and the lie of the country. Some localities or roads may be of such great importance that a single company would not be strong enough to ensure safety. In such circumstances do not hesitate to put two or more companies up in line with the supports, or close to wherever you make your main resistance. It may often occur, for instance, that villages or bridges are in the outpost line, and that we may mean to hold them; in such a case a single outpost company may be altogether too weak;

when this happens use your common sense and do not think too much about "the book."

Line of Resistance—The Pickets or Supports. Another subject which is constantly hotly argued, is whether the picket or support line should be the line of resistance, and whether it is better to bring the supports up to the pickets, or to allow the pickets to fall back on the supports. It is almost impossible to arrive at any conclusion on a general question of this sort; but if we keep a firm grip on our common sense, and have any knowledge of what night fighting is like, we ought to be able to deal with the situations as they arise.

As regards the picket line, if it happens to run along a river or some other easily defended position, this alone may be quite sufficient to justify you in making your main resistance along the pickets. Another consideration is: does the lie of the country permit of the supports being brought up quickly and not exposed to fire? You may remember that earlier in this letter I referred to the difficulty of bringing supports up to reinforce troops which are hotly engaged. Bear this in mind, it is a real difficulty, but you may be able to make arrangements to meet it—such as having standing patrols or sentries well out to the front, in order to give plenty of warning, or making obstacles along the picket line which will be sure to delay the enemy, or selecting a covered line by which the supports can come up. Also, if you have made up your mind to bring up your support to reinforce its pickets, there is nothing to be gained by keeping the support too far behind. In fact, in certain cases (villages, bridges, etc.) it might be placed almost up in line with the pickets. Do not allow yourself to be tied down by a pedantic reading of the Regulations.

As regards the resistance being made along the line of supports, the advantage is that there is less chance of the position being surprised; and also we must credit the pickets with doing their duty, and their fire should certainly throw the attackers into confusion. On the other hand, there is the risk that the pickets may wait too long or be surprised, and the enemy may come in with your pickets in such a way as to prevent the supports firing without hitting their own friends. But if you thoroughly realize the danger, and explain the matter to the pickets they ought to be able to get back without this happening.*

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*Just consider the case of the Boer picket at the foot of Surprise Hill. If it had been well handled, and had opened rapid fire and then fallen back 50 yards or so, what would have been the result? You will probably agree that the attacking force would have been in an ugly position, and the Boer picket would have carried out its mission successfully. But say the Boers had tried to support their picket instead of the picket falling back, the probability is they would have got into considerable confusion coming down the hill, and goodness only knows what the ultimate result would have been; so in a case like Surprise Hill it would be better to let the pickets fall back, and naturally there would have been no object in making the pickets unnecessarily strong.

To sum up, the main things to consider are:

1. That if the country is very open (as is the case in South Africa and in many parts of the Continent), then the enemy may get between the pickets and the supports.
2. If the country is very enclosed the enemy's advance may be limited to the roads; in such cases there should be little risk of the enemy getting behind the pickets, and the latter, if well posted and intelligently handled, should be able to throw the attackers into confusion and get back to the support without becoming too closely engaged.
3. If the line of resistance is made on the picket line, do not keep the supports too far back (especially at night), and pay particular attention to the question of bringing up these supports.
4. If the line of resistance is to be the support line then pay particular attention to the question of how the pickets are to fall back, and remember that in these circumstances the pickets should not be made too strong. All you want the pickets to do is to give you warning, and to delay and throw the enemy into confusion. You particularly wish to avoid being thrown into confusion yourself, and the fewer men (within reason) that you have in front of your main line of resistance the better.

Outpost Reserve. There is considerable difference of opinion on the question of a reserve for outposts. The old Field Service Regulations was rather vaguely worded, and many officers stoutly maintained that an outpost commander was not entitled to keep a reserve under his own command; and they quoted paragraphs of the old Field Service Regulations in support of their pedantic views. The revised edition is rather clearer and devotes a short section (F. S. R. page 105) to the subject. Short as this section is there are two paragraphs in it that are certainly open to argument:

Section 80, par. 1, reads:

"A reserve will be used *only** when the outpost force is large, when the outposts hold the ground which is to be occupied by the main body in case of attack, or when the outposts are in contact with the enemy's outposts."

Why is the word "only" used? And what force is considered "large"? It would not be difficult to imagine circumstances other than the above which might justify the outpost commander in keeping a reserve.

Section 80, par. 2, reads:

"If required it (the reserve) will be detailed by the commander who appoints the outpost commander, and should always be formed of a complete unit, with mounted troops and generally some guns attached."

This paragraph, if taken literally, might well lead us into trouble.

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*The italics are the authors.

Cases will occur over and over again when only the outpost commander can form an opinion as to the strength of the reserve, and even he can only make up his mind after studying the situation on the ground. The supreme commander can certainly say how strong the outposts ought to be, as he is the best judge of the amount of resistance the outposts should offer, but he can not possibly say how many men will be required for the pickets, supports, or reserves, until he has seen the ground. You know as well as I do that, unfortunately, there are certain officers who read the Regulations and attach more importance to the words than to the spirit. The result is that the supreme commander tells off, say, two battalions for the outposts; the outpost commander divides his ground among his outpost companies and finds he has three or four companies unemployed; he then recollects Section 80, par. 2, and imagines that he would be wrong to keep the three or four companies as a reserve (or even to strengthen the supports), and, impossible as it may seem, he sends the three or four companies back to the main body.

The truth is some officers would like to have war so cut and dried as to enable a stupid, but diligent, man to compete with an adversary who is gifted with some natural talent for the business. Our Regulations require to be very carefully worded, and I, for one, would be glad to see Section 80 redrafted, so as not to admit of any misunderstanding; as it stands at present it hampers rather than assists, and, if taken literally, may lead officers positively astray. It is quite impossible to say that an outpost reserve will *only* be used in certain enumerated conditions; no man's imagination can picture every imaginable case that is going to happen in war. The Regulations should be altered so as to make it quite clear that an outpost commander should keep a reserve if he considers it advisable.

There is another small point in paragraph 2 (Section 80) which might also be altered, namely, the use of mounted troops and guns. The literal reading of the Regulation lays down that if a reserve is employed it should *always* have mounted troops attached. This is probably a slip.

All through this letter you will notice that stress has been laid on the importance of taking particular precautions against surprise. This especially applies to a force making a night attack, or otherwise moving about at night. There is nothing so likely to lead to panic and disaster as the unexpected opening of fire upon a body of troops. It needs a more graphic pen than mine to describe the actual effect of the bullets. Officers and non-commissioned officers, upon whom others may be waiting for orders, may be shot down, and no one may be aware of the fact; the men are apt to throw themselves on the ground or break the ranks in their natural desire to seek cover, the effect, of course, being that control is lost. It is, therefore, of the utmost importance that a commander should avoid placing his troops in such a position, and remember that when a surprise of this sort takes place the man to blame is the commander—the best troops in the world will seldom stand such an ordeal.

I have tried to impress upon you the necessity for explaining to all ranks what is to be done; these explanations may permit of action being taken at once without orders (which ten to one will never reach the troops); but your object as a commander should be to avoid ever placing your troops in such a hopeless position, and it is about this that I propose to say a few words before closing this letter.

If the circumstances are favorable, the following may be the best way of securing the column from surprise. You will agree that there are two methods of achieving this security. First, by covering your advance with a certain number of patrols or scouts, whose duty it is to give warning of the enemy's presence. Secondly, you may possibly be able to locate the enemy before you start on the night advance; if you can keep such a close watch on him as to be sure of receiving warning if he moves—then you should be safe from surprise.

The first of these methods should never be neglected, and you would be well advised if you also employed the second whenever it is possible to do so. Perhaps, if I give you two examples it may assist you to understand what I mean.

During the South African War a small column was going to make a night march out of a town. It was known that the Boers had a picket watching the road which the column was going to use; the picket was always there by day, but it was not known for certain whether it remained out during the night or not. The afternoon before the column moved out a few scouts were sent to observe the Boer post, which could be seen some distance away. As night came on the scouts drew in closer and closer to the Boers, and, eventually, by the exercise of considerable daring and caution combined, they were able to observe the Boers depart. To return to the column. It moved out after dark, and when about a mile away from the Boer post it was met by a scout on the road, who reported that the rest of the scouts were ahead, and that it was thought that the enemy had gone. Proceeding with caution the column met another scout who said the Boers had gone, and the scouts were in occupation of the small pass ahead. You may say that there is nothing in what I have related, as the enemy had gone. Quite so, but you can apply this procedure to other cases and it may be useful. Say the enemy had remained, there would have been no question of a surprise, and in any case the column was able to move forward without having to delay to scout, and everyone must have felt an unwonted sense of security.

The second example took place in Africa during operations against natives. There were some wells, about 45 miles from one of our posts, which had to be seized. The enemy were believed to be in occupation of the wells—strength unknown. Some twenty scouts were sent out to locate and picket the enemy.

As in the previous case the column during its night march picked up a scout on the road—this time about 10 miles from the objective; he reported the wells held, and that another scout further on would give more news. The next scout was met and he reported much the same, and in his turn led the column closer to the scouts. Eventually the man in charge of the scouts was met, and he explained all he knew to the column. The rest of the story does not concern us, and in any case the enemy bolted so rapidly when the advance was made at dawn that only a few shots were fired. But as in the example from the Boer War, this incident may assist you to apply the idea of picketing your enemy, and may be of use to you in securing yourself from a surprise encounter in the dark.

The Colbert Shoals Canal, Tennessee River, Alabama

BY

Maj. H. BURGESS
Corps of Engineers; Member American Society Civil Engineers

(Continued from the November number.)

It was assumed in the preparation of these plans that the canal would not be used when there was a 7-foot stage at the head; that is, when elevation of river surface at head of canal was above 41.0, as water would then have begun to flow out of the canal over the long spillway just above the guard lock. But since the draw toward this wall, produced by water flowing over it, would not interfere until there was considerable depth to the out-flowing sheet of water, the canal would probably have been navigable almost to the stage at which the guard lock gates were submerged. Below the 7-foot stage the water in the upper section of the canal would rise and fall corresponding to the stage at the head, and there would be no appreciable current in it, except the upstream current produced by storm water discharge of the small tributary streams. As soon as the water rose above the crest of the long spillway, a flow in the canal would begin and a slope would be established from the head of the canal nearly to the guard lock. It was calculated that the discharging capacity of this mile-long spillway would give to the canal surface the same slope as in the river by the time the guard lock gates were topped, when the elevation of the water in the canal at the guard lock would have been 43.0 and at the head of the canal 45.6, or 11.6 on gage No. 1.

Below the guard lock the water in the canal would have stood at elevation 34.0, the elevation of the spillways, except when temporarily a foot or two higher due to storm water from the tributaries, until the canal began filling through the weirs. The Boones Branch, or uppermost weir, would have begun flowing under average conditions at about the stage of 7.7 to 8.0 on gage No. 1, and the water brought in at this weir would have been discharged over the weir or weirs below. The next, or Ross Branch, weir would have been reversed and begun inflowing at about the 9-foot stage. It was very difficult to predict exactly when the other weirs would begin to inflow, but it was concluded that the lowest, or Chickasaw weir, and possibly the Bledsoe, would continue to outflow, and that the three uppermost weirs would bring in more water than the two lowest weirs would discharge, and that by the time the water above the guard lock reached 43.0 it would be about 41.5 just below, and very near 37.0 at Chickasaw Branch, or practically even with top of lift lock gates. A further increment of rise, and the guard lock and the lift lock gates would both be topped; and after that it was supposed that the slopes in the river and in the canal would have been nearly the same, but with sufficient difference in head to cause inflow over the guard lock gates and through the three upper weirs, and outflow over the lift lock and the two lowest weirs. At still higher stages, after the canal bank (natural surface of ground) was submerged, the slope in river and canal would probably have been exactly the same, and there would have been no cross-flow at any point along the canal.

On a falling river when the conditions of slope in river approached maximum the lift lock gates would have been first uncovered, after which the water coming in over the guard lock gates and the upper weirs would have been discharged over the one or two downstream weirs, and later the guard lock gates would have been uncovered, and the river would finally have dropped below elevation 34.0 opposite the upstream weir, leaving the canal surface at 34.0.

On a falling river when the slope in the river was near minimum, the guard lock gates would be the first to be uncovered, after which there would probably have been some inflow through upstream weirs, the water passing out over the lift lock gates. A further fall would bring out the lift lock gates, and there would be a slight inflow over the upper weirs and outward flow over the lower; and, as before, this would continue until the river opposite the upper weir dropped to elevation 34.0.

The modified plan apparently would have given a canal answering all necessary requirements as to navigation and as to safety of structures. The advantage of moving the guard lock downstream was, in the main, the fewer chances of damage to the structures and embankments from water flowing into the canal over the guard lock gates. The lesser length of canal trunk to be filled through the weirs would tend to reduce the fall over the guard gates at the epoch of submergence and at the same time to increase the depth of water into which this overflow fell. As stated before, the calculations indicated that the water just below the guard gates would be at elevation 41.5 when above it had reached 43.0 (elevation at head 45.6), which would give only 1.5 feet fall into a depth of 15 feet. The fall over the embankment into the canal would never be over 1.5 feet, provided that between the guard lock and uppermost weir the top of the embankment was at elevation 43.0 or higher. It would, of course, be impossible that this building up of water surface in the canal could take place if the widths of weirs were not so adjusted that the upstream weirs would bring in more water than could be discharged over those below. With the guard lock at the head of the canal it would be far more difficult to obtain the same depth of "back-filling" at the epoch of submergence.

It may be noted that in the previous plans only the 5,000 feet of the canal opposite the bluff point was to be in the river bed, while in the new plan about 13,000 feet was to be so located. The subsequent modifications of the project made no change in location of this upper 13,000 linear feet of canal.

OMISSION OF THE GUARD LOCK.

The Board of 1902, which passed on the question of the omission of the guard lock, as then proposed by the district officer, apparently objected to its elimination because "there would exist in the canal a current as soon as the river commences to rise above low water;" this current, and especially the draw over the long weir, being dangerous to navigation. The Board remarked, "A guard lock would prevent any flow into the canal until the river should rise to a stage that would permit outside navigation." To fully understand these objections, it must be remembered that the plans considered by the Board not only provided for the omission of the guard lock and the location of the 13,000 linear feet of canal in the river bed, but fixed the top elevation of the long spillway portion of this concrete wall *at elevation 34.0,* and provided five spillways in the shore section of the canal, also at 34.0 elevation. The fixing of the crests of spillways at elevation 34.0 was for the purpose of enabling them to discharge the maximum calculated run-off from the tributary streams without allowing the canal surface to rise above the top of lift lock gates, and thereby put the canal out of service before navigation was possible in the open river. Under this plan water would have begun to flow over the upper part of the long spillway as soon as a stage was reached of 6 inches above *assumed extreme low water* (would be *flowing at all times at ordinary low water*), and the outward flow over this part of the wall would have rapidly increased in volume as the river continued to rise, until at the 7-foot stage, when navigation was supposed to be possible over the shoals, the depth of water on the long spillway would have been from 3 to 5 feet, and the draw over this part of the canal wall would have seriously interfered with the navigation of the canal. Under these conditions the Board's decision to retain the guard lock was obviously a sound one.

The changes next suggested followed as a natural consequence from a consideration of the objections stated by the Board to the previous proposal; the changes being, to make practicable the omission of the guard lock by increasing the height of the spillways and of the lift lock walls and gates sufficiently to prevent any outflow from the canal until the river reached a stage at which open-river navigation was possible. It was decided that the open river could be navigated at the 7-foot stage on gage No. 1, and consequently the crests of spillways were fixed at elevation 41.0; but the tops of lift lock walls and gates were to be at elevation 42.0, in order not to have them topped by the temporary rise in canal due to storm water from the tributaries discharged into the canal when it was already near the 41.0-foot level. Other changes proposed were, to shift location of the lower part of the canal back to the center of the right-of-way and to waste the excavated material on both sides of the canal, saving thereby about 100,000 cubic yards of excavation and reducing the average height to which the waste material must be lifted; to fix the minimum height of the river bank of the canal at elevation 43.0, or 2 feet above spillways, and, of course, to omit the guard lock, the omission of which was the object of the study. The report of the district officer containing these recommendations was submitted to the Chief of Engineers in May, 1904, and soon after this the suggested shifting of location for the lower part of the canal trunk was authorized, but the other changes were discussed at length in correspondence between the district officer and the Department, and later by a Board appointed in 1905 for the express object of passing on the suggestions of the district officer.

The chief objection to the omission of the guard lock having been overcome by the raising of the lift lock walls and gates and the spillways, the merits of the recommended changes were to

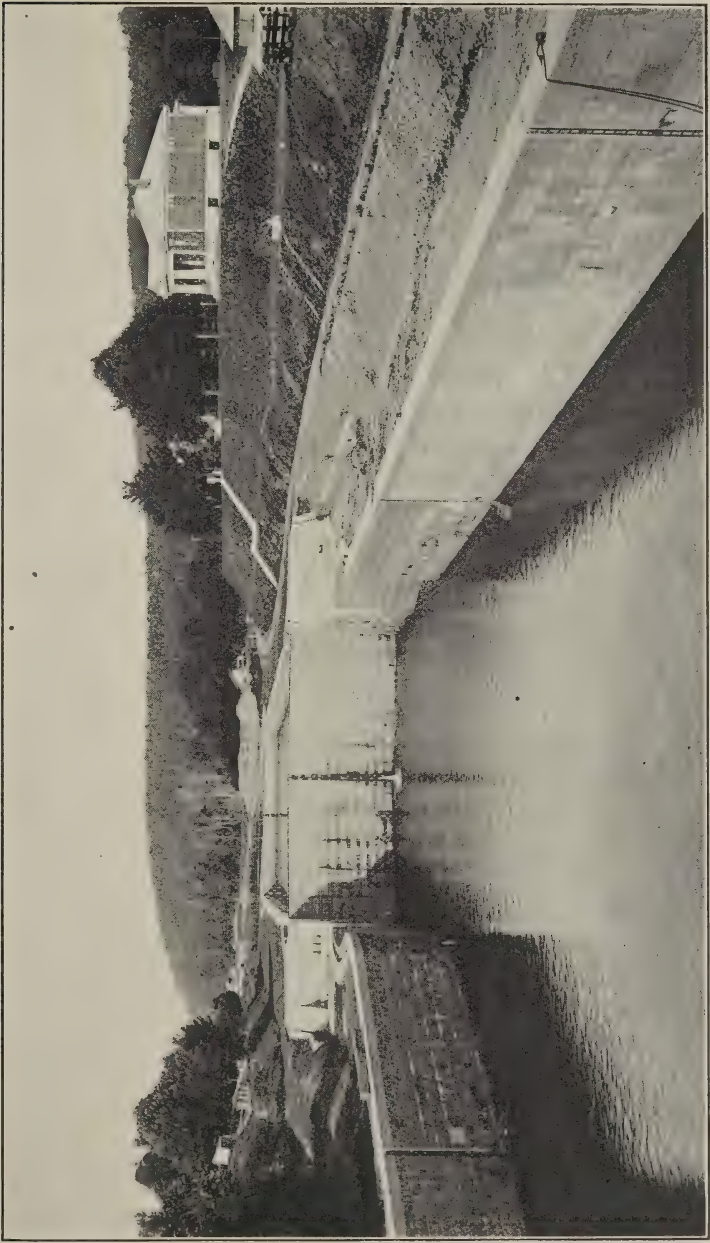

Fig. 9. Lock and artificial mound from derrick boat in lower approach, looking upstream.

be determined by a careful comparison between the advantages to be secured by omitting the guard lock and disadvantages which might arise therefrom. The advantages were, the estimated saving of about $100,000 in cost of construction and of about $3,000 to $3,500 in annual cost of operation and maintenance, and, more important, the greater simplicity of operation and ease of navigation. The several objections made to the omission were, (1) the possibility that the walls of the lift lock would not have sufficient stability against overturning if given 4.5 feet additional height; (2) the possible injurious effects of storm water from the tributary streams, forced by the raising of the spillways to pass out upstream through the head of the canal; and (3) the possible increase in accumulation of drift and deposit in the canal due to allowing free entrance of the river into the upper end of the canal. As to the first objection, calculations showed that the walls of the lift lock had ample thickness to permit the 4½ feet additional height. Estimates and calculations of the maximum probable run-off from the tributary watershed indicated the run-off had been overestimated in the past and that no seriously obstructive currents were likely to be caused in the canal at the time of maximum run-off; and, further, that these currents would not be likely to cause much erosion, although the slopes of the canal were, nevertheless, to be paved from bottom to top. A slight interference with navigation would be theoretically possible at the stage when the water in the canal was between elevations 40.0 and 41.0, when a severe storm might produce a quick run-off from the tributary basin and might raise the water in the lower end of the canal above elevation 42.0, overflowing the lock gates and putting the lock out of service. The river then being below the 7-foot stage, navigation of full capacity would be interrupted for the short period that the lock gates were topped; but such interferences would be of very infrequent occurrence, and for very limited periods, and would therefore be of trivial importance. In reference to the question of accumulation of drift and deposits in the canal, the district officer submitted the following discussion:

> Under the present approved project deposits will doubtless be formed in the canal throughout its entire length, and will require periodical removal. They will come from the river and from the several small streams that enter the canal. The latter, however, are not of so much importance, and may be disregarded in this discussion, as they would not be affected by the proposed changes, since they discharge into a pool in either case. The deposits from

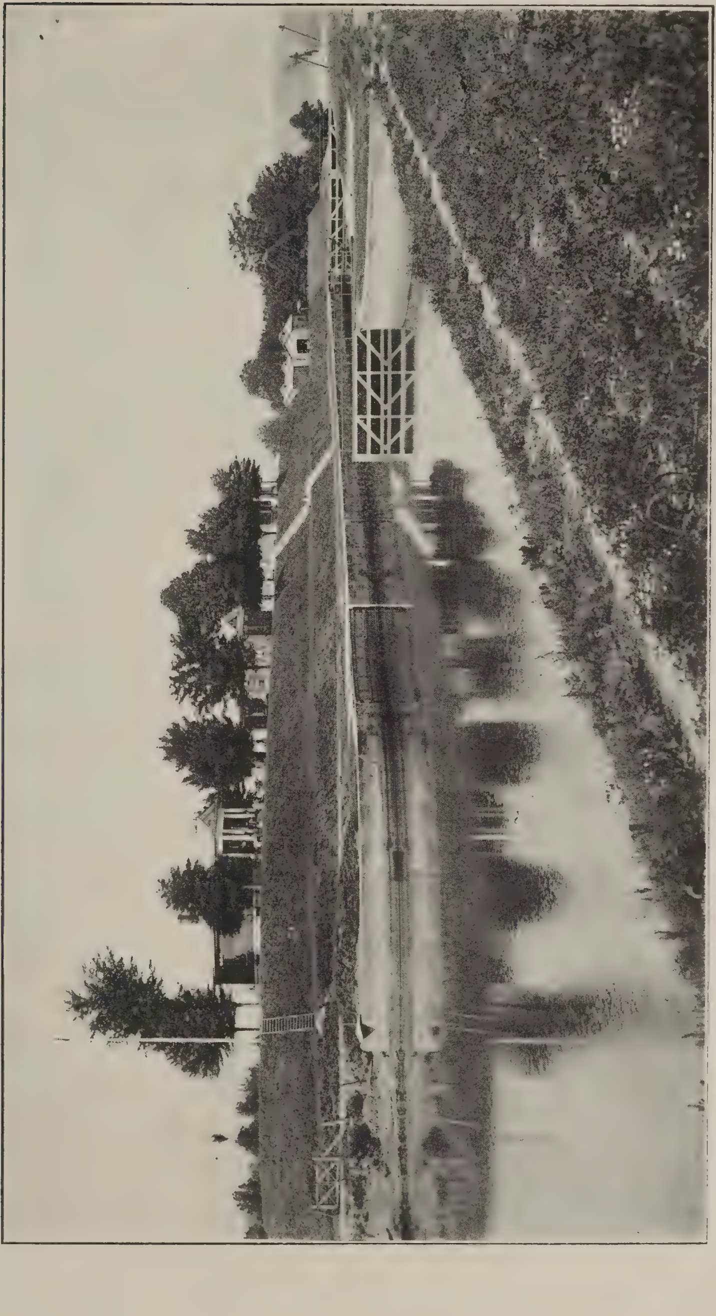

Fig. 10. Lock and artificial mound at lower end of Colbert Shoals Canal, from north embankment above lock.

the river water will be formed principally where the river water enters the canal. Below the 7-foot stage, water enters the section of the canal between the two locks only through the guard lock; but the river has direct access to the head of the section above the guard lock. This section forms a pool about 2.3 miles long, in which the water surface rises and falls to correspond with the changes of stage in the river at its head. This would be practically a pool of still water. The greatest mean velocity at the head would be about one-sixteenth foot per second, due to filling the pool at the maximum rate of 3 feet per day, as indicated by the hydrographs for ten years for the gage at the head of the canal. For stages under 7 feet, therefore, it is apparent that the deposits would accumulate principally at the head of the canal.

For stages over 7 feet, the river water will not only enter the section above the guard lock, but will also enter the section between the two locks, over the weirs (at elevation 34.0), over the guard lock gates (at elevation 43.0), and finally over the general embankment. Moreover, at these stages there will be a current along the entire canal, of less velocity than in the river, but sufficient to largely increase the volume of river water contributing to the sediment. When we consider also that the percentage of water in suspension is greater during these higher stages, it becomes apparent that they will form the principal deposits, and that the entire length of the canal will be exposed to them.

Now, assume that the guard lock is omitted and the other changes made as recommended. Below the 7-foot stage the entire canal forms a pool in which the water surface rises and falls to correspond with the changes of stage in the river at its head, where alone the water has access to the canal and where the greatest mean velocity (on rare occasions) would be about one-sixth of a foot per second. It is apparent that during these stages (below 7 feet) there would be greater volumes of river water entering the canal, and somewhat greater deposits; but these would form at the head, as before, and would probably be of little importance, as the percentage of matter in suspension is smaller at these stages and the volume of water entering the canal very much less than at the higher stages.

As before, therefore, the principal deposits would be formed during the higher stages (above 7 feet); but it is to be noted that now, on account of the greater elevation of the weirs, a greater rise in the river would be necessary to produce a flow in the lower part of the canal, and, moreover, all the weirs when in action now discharge from the canal into the river, instead of from the river into the canal, as was the case with some of them before. For some of the higher stages, therefore, the lower part of the canal is less exposed to deposit without the guard lock than with it. After complete submergence of the work, when the formation of deposits would doubtless be most active, it is not seen that the presence of the guard lock would offer any advantage. As an

> additional obstruction it might even be expected to cause increased deposits. In short, it is believed that the above discussion leads fairly to the conclusion that the guard lock, under the peculiar conditions of this project, affords no material protection to the canal against deposits.
>
> The question of drift . . . remains to be considered. The presence of the guard lock would doubtless tend to lessen any trouble from this source, but in order to have any practical efficiency for this purpose it should be placed at the head of the canal instead of about 2.3 miles below, as it is in the present project. Little trouble is anticipated from drift, in any case, since the channel opposite the head of the canal is near the right bank. . . . My conclusion, therefore, under this head is that with either plan there may be some trouble from drift, . . . but that the omission of the guard lock will have no marked effect on the source of trouble.*

The studies made under direction of the district officer included calculations to determine the slope of water in the canal at stages above 7 feet on gage No. 1, up to which stage the canal would be a pond. These calculations and the curves formed from them were submitted to the Board. The substance of the hydraulic studies was: That soon after the water at head of canal passed above elevation 41.0 (7-foot gage), water would begin to flow over the *upper* end of the long concrete weir, and that when elevation 42.0 was reached water would be flush along the concrete wall as far as the spillway section (this could not have been exactly true, of course, as some slope must needs exist to cause the flow of water over the spillway), and that water would then be pouring over the long spillway in a sheet of diminishing thickness. When elevation 43.0 (9-foot gage) was reached the 42.0 concrete wall would be submerged about one-half its length, from its head to a point where the river would be at elevation 42.0; in other words, the canal above this point would be part of the open river. A thicker but diminishing sheet of water would be pouring out over the upper part of the concrete spillway, and below the end of this sheet the canal would still be at elevation 41.0. At the 10.5-ft. stage (elevation 44.5) the concrete wall would be submerged throughout, and at the lower end the canal level and the river surface would both be just level with the spillway section, or at elevation 41.0, the canal below also being 41.0. At the 11.6-ft. stage (elevation 45.6) it was thought that the canal surface at the upper end of the shore section would have risen to elevation 42.5, but that all of the water entering the shore section would be passing out at the Boones and Ross weirs, leaving the canal surface below the latter still at 41.0. The calculations indicated that at the 13.1-foot stage (elevation 47.1) the river would be above all except the Chickasaw weir, and the canal would have the same slope as the river as far down as the Bledsoe weir, and at an elevation below Bledsoe of about 41.0. A further rise to a 14.0-foot stage would just top the lift locks (elevation 42.0), and the canal would then have nearly the same slope as the open river, with only a slight fall over the lock gates. The canal embankment (at elevation 43.0, except where excess material gave extra height) would begin to be submerged at Shades Branch when gage No. 1 was at about the 12-foot stage (elevation 46.0), at the 13.1-foot stage would be submerged as far as Boones Branch, and entirely so at about the 15-foot stage. On account of the fact that the weirs were to be 2 feet below the top of the embankment, and the fact that no part of the embankment would be submerged until the canal surface and the river opposite the point of submergence were at the same elevation, it was thought no cross currents could attack and endanger the embankment. Adjoining the canal on the left, at the lower end, and extending for a considerable distance below the lock, the natural surface of the ground is low; but it was not thought likely that the water flowing out of the canal and over this low ground would cause any injurious scour, since by the time the outflow began the water would have backed up from below to such an extent as to give considerable depth in this swale, and since the head for such outflow would be slight.

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*It may be mentioned here that a later slight modification of plans provided for a drift chute through the concrete wall near its lower end, to be closed by a bear-trap dam; and that the provision for this drift chute was retained in the plans under which the canal was actually constructed.

In view of the results of the studies of the district officer and his assistants, which showed that the omission of the guard lock would not be a source of danger nor inconvenience and yet would considerably reduce the cost of the canal, the Board recommended the approval of the suggestions of the district officer, and this recommendation was approved by the Secretary of War. Except in minor particulars, the canal was constructed according to this 1905 "approved project." The minor departures from these plans may be noted in the description of the canal as actually constructed pages 80-82). The estimated cost of the completion of the canal, as furnished to the Board, including expenditures to date, was $2,850,928 for the new plans and $2,951,045 for the previous project.

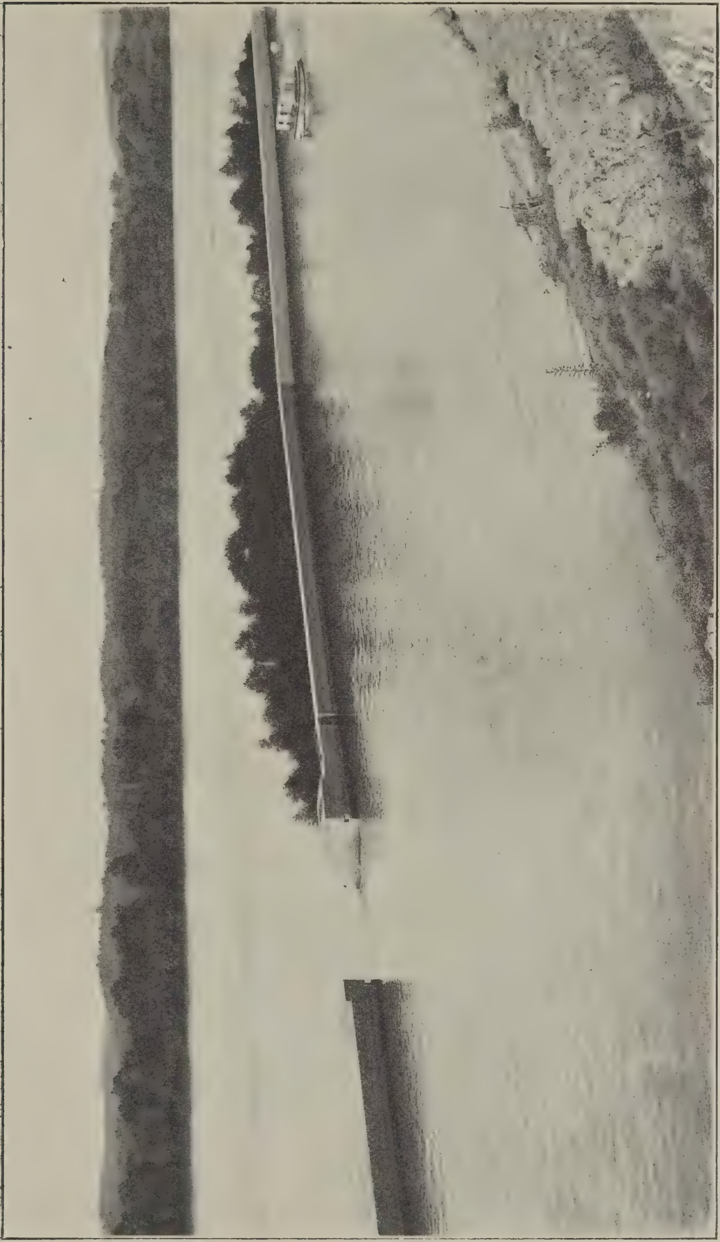
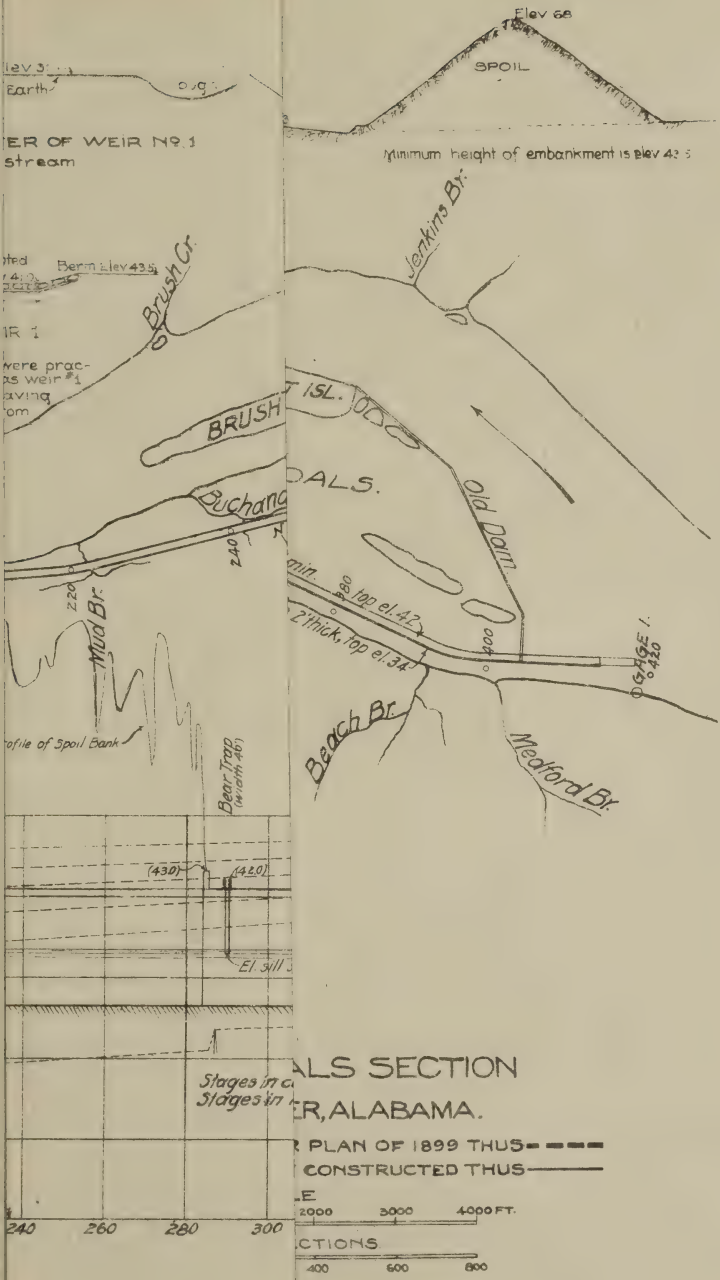


Fig. 11. Bear-trap drift sluice in lower end of concrete wall, looking across canal into the river.

CANAL AS ACTUALLY CONSTRUCTED.

By the aid of Plate III and the following details it is believed that there will be no difficulty in understanding the details of the plans under which the canal was completed and opened to navigation on December 14, 1911. Beginning at the head, the canal is formed by a river wall, approximately paralleling the river bank, for a total distance of 13,429.6 feet, below which is the shore section of the canal. The river wall for the first 6,123 feet is a rock-fill embankment with minimum top thickness of 40 feet, and with minimum top elevation at 42.0, canal datum. This embankment was formed from rock excavated from the trunk of the canal, piled on and around the cofferdam constructed by the contractor for unwatering the excavation. Deposit from the river has fairly well consolidated the rock mass, and the surface is now nearly covered with a growth of vegetation, giving the embankment the appearance of a natural island. At the foot of the canal slope of this embankment there is a toe wall of concrete, 2 feet thick, reaching to elevation 34.0, or 0.5 foot above assumed extreme low water in the canal; the purpose of this concrete wall being to prevent loss of depth in the canal at low water by leakage through the rock-fill. Below the rock-fill embankment the canal wall is of concrete, with width of 4 feet for the upper 3.75 feet, below which the river face has a batter of 3 on 1, while the canal face is vertical. The top of the upper 442.4 linear feet of this wall is at elevation 42.0; the next 6,651.4 feet is 1 foot lower, and forms a weir for the river section of the canal. The top elevation of the lower 106.4 feet is at 43.0. About 600 feet from the lower end of the concrete wall there is a drift chute 40 feet wide, with sill at elevation 33.0, closed by a movable gate of the bear-trap type. The distance between the canal wall and the river bank varies from 110 to 250 feet. Rock excavation was required in the upper 7,300 feet of the river section of the canal, in order to give the proposed depth at low water of 7 feet. This excavated cut has a minimum width of 147 feet and a maximum width of 243 feet; but there is no apparent reason for this extra width, as it is not suitably located for a passing basin.

The shore section of the canal begins near Shades Branch, at the lower end of the concrete wall, and is 27,450 feet long, ending at the head of the lift lock. The bottom of the excavated channel is at elevation 26.5, except where extra depth was given for drainage during excavation. The bottom width of the cut is 112 feet; and

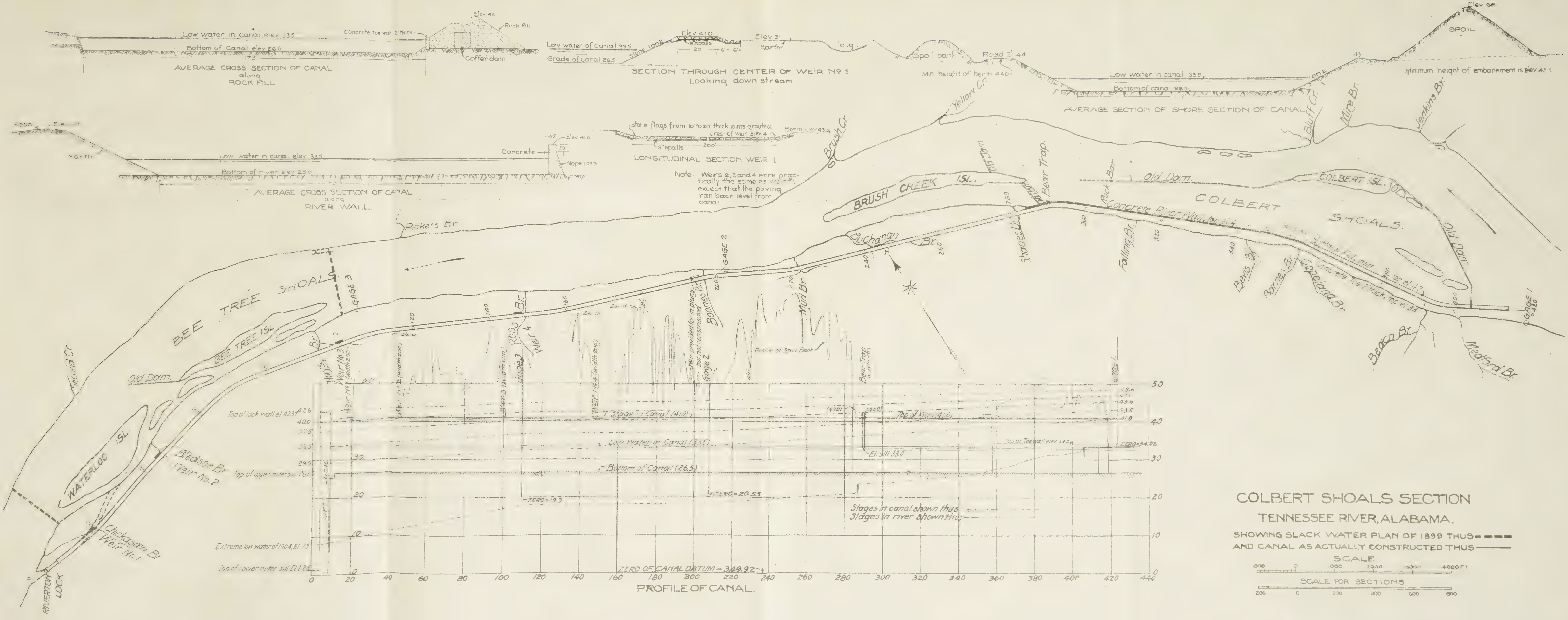

Elev 68
SPOIL
Minimum height of embankment is elev 43.5
lev 3
Earth
ER OF WEIR Nº 1
stream
Berm Elev 43.5
Brush Cr.
Jenkins Br.
IR 1
were prac-
as weir #1
aving
om
BRUSH
ISL.
DALS.
Buchana
Old Dam
240
220
Mud Br.
380
top el. 42
2' thick, top el. 34
400
GAGE 1
420
Beach Br.
Medford Br.
ofile of Spoil Bank
Bear Trap (width 46')
(43.0)
(42.0)
El. sill
Stages in
Stages in
240
260
280
300
LE
2000
3000
4000 FT.
CTIONS
400
600
800

ALS SECTION

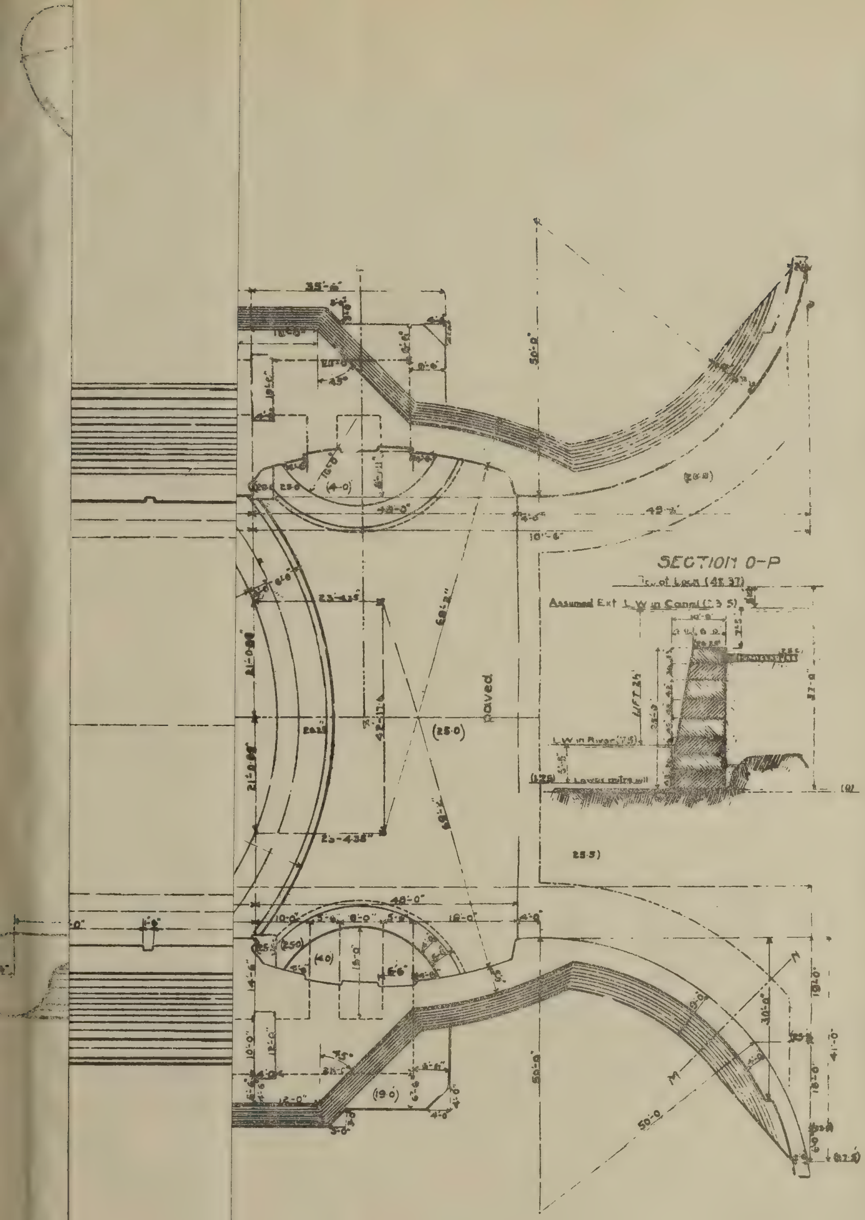
ER, ALABAMA.

R PLAN OF 1899 THUS ▬ ▬ ▬

CONSTRUCTED THUS ———


Low water in Canal elev 33.5
Concrete toe wall 2' thick
Elev 46
Rock fill
Bottom of Canal elev 26.5
Coffer dam
AVERAGE CROSS SECTION OF CANAL along ROCK FILL
Low water of Canal 33.5
Grade of Canal 26.5
Elev 41.0
Elev 3'
Earth
SECTION THROUGH CENTER OF WEIR No 1 Looking down stream
Spoil bank
Road El 44
Min height of berm 44.0
Low water in canal 33.5
Bottom of canal 26.5
AVERAGE SECTION OF SHORE SECTION OF CANAL
Elev 68
SPOIL
Minimum height of embankment is Elev 43.5
Earth
Low water in canal elev 33.5
Concrete
Elev 41.0
Slope 1 on 3
Bottom of river elev 25.0
AVERAGE CROSS SECTION OF CANAL along RIVER WALL
Stone flags from 10" to 20" thick joints grouted
Crest of weir Elev 41.0
Berm elev 43.5
8" spalls
LONGITUDINAL SECTION WEIR 1
Note:- Weirs 2, 3 and 4 were practically the same as Weir No 1 except that the paving ran back level from canal
Yellow Cr.
Bluff Cr.
Mire Br.
Jenkins Br.
Brush Cr.
BRUSH CREEK ISL.
Old Dam
Bear Trap
Rock Barr
Old Dam
COLBERT ISL.
COLBERT SHOALS
Concrete River Wall
Old Dam
Picke's Br.
Buchanan Br.
Shoals Br.
Falling Br.
Bevis Br.
Barnes Br.
Copeland Br.
Beach Br.
Medford Br.
GAGE 1
GAGE 2
GAGE 3
Boones Br.
Mud Br.
Ross Br.
BEE TREE SHOALS
BEE TREE ISL.
Old Dam
Second Cr.
WATERLOO ISL.
Bledsoe Br.
Weir No. 2
Chickasaw Br.
Weir No. 1
RIVERTON LOCK
Weir No 3 (width 200)
Weir 4
Weir provided for in plans but not constructed
Profile of Spoil Bank
Top of lock wall el 42.3
Top of upper miter sill 26.5
Stage in Canal (41.0)
Top of Wall (41.0)
Low Water in Canal (33.5)
Top of Toe wall elev 34.0
ZERO = 34.02
El. sill 33.0
Bottom of Canal (26.5)
ZERO = 20.55
ZERO = 9.3
Stages in canal shown thus
Stages in river shown thus
Extreme low water of 1904, El. 7.5
Top of lower miter sill El 1.0
ZERO OF CANAL DATUM = 349.92
0 20 40 60 80 100 120 140 160 180 200 220 240 260 280 300 320 340 360 380 400 420 440
PROFILE OF CANAL.
SCALE
1000 0 1000 2000 3000 4000 FT
SCALE FOR SECTIONS
200 0 200 400 600 800

COLBERT SHOALS SECTION
TENNESSEE RIVER, ALABAMA.
SHOWING SLACK WATER PLAN OF 1899 THUS - - - -
AND CANAL AS ACTUALLY CONSTRUCTED THUS ———


35'-6"
19'-6"
20'-0"
45°
48'-0"
50'-0"
49'-6"
10'-6"
4'-6"
SECTION O-P
Top of Lock (48.37)
Assumed Ext. L.W. in Canal (23.5)
10'-0"
LIFT 24'
37'-0"
L.W. in River (7.5)
(12.5) Lower mitre sill
(0)
(25.0)
Paved
68'-2"
25'-4.38"
21'-0.88"
42'-1.76"
(4.0)
(25.0)
(19.0)
(25.5)
12'-0"
16'-0"
18'-0"
30'-0"
41'-0"
50'-0"
(12.5)

TENNESSEE RIVER

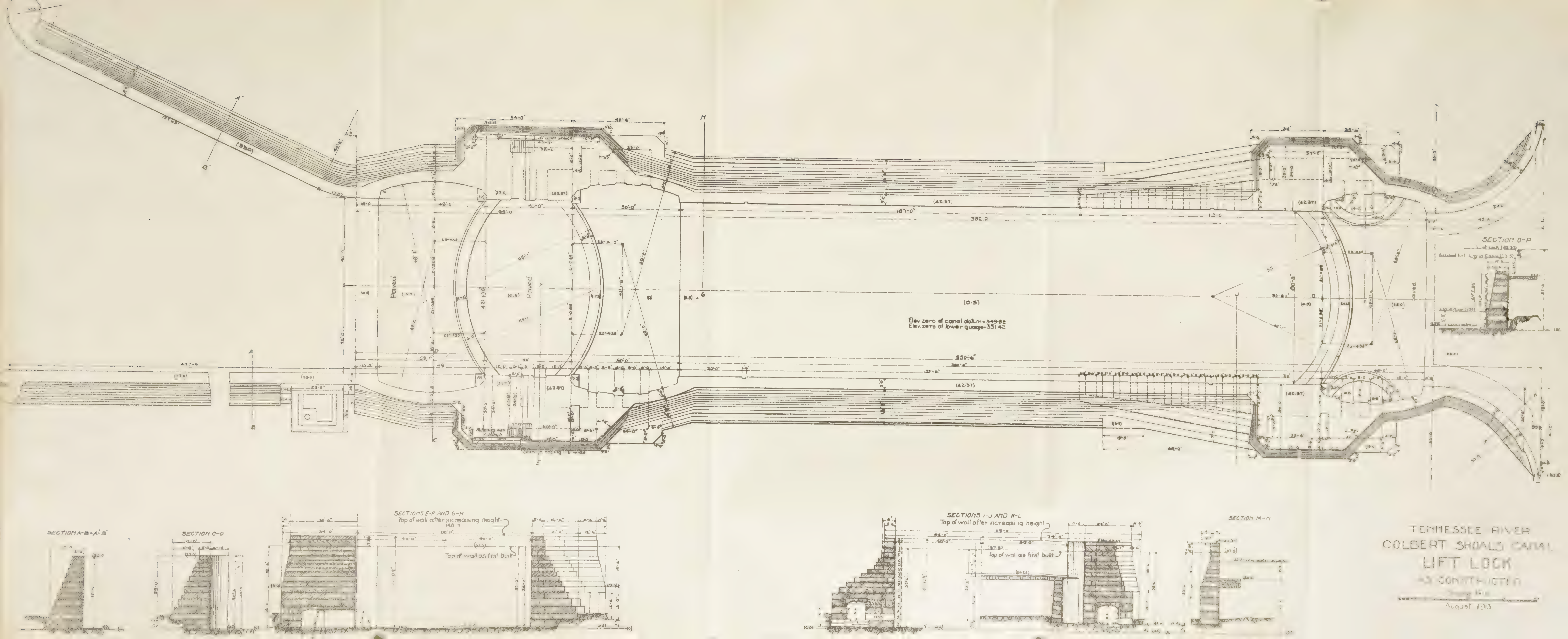
COLBERT SHOALS CANAL

LIFT LOCK

AS CONSTRUCTED

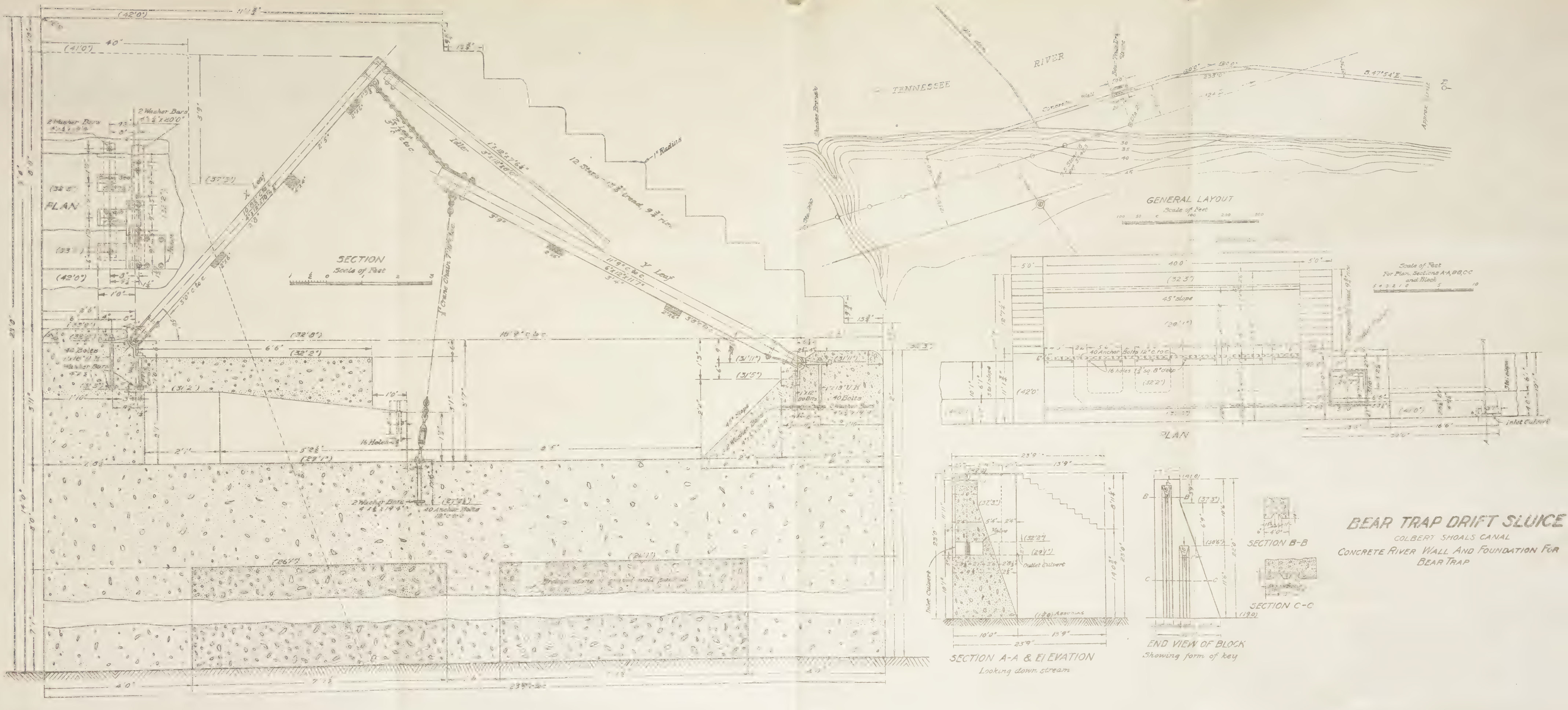
Scale 1"=16'

August 1913


SECTION O-P
Paved
Elev. zero of canal datum = 349.92
Elev. zero of lower guage = 351.42
(0.5)
(42.37)
350.0
550'-6"
Retaining wall
Step in coping 1'-6" wide
SECTION A-B-A'-B'
SECTION C-D
SECTIONS E-F AND G-H
Top of wall after increasing height
Top of wall as first built
SECTIONS I-J AND K-L
SECTION M-N

TENNESSEE RIVER
COLBERT SHOALS CANAL
LIFT LOCK
AS CONSTRUCTED

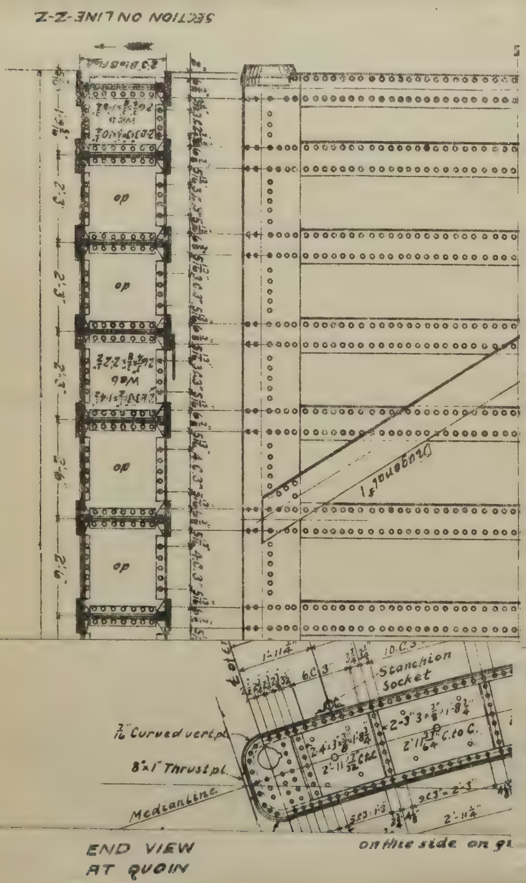
August 1913

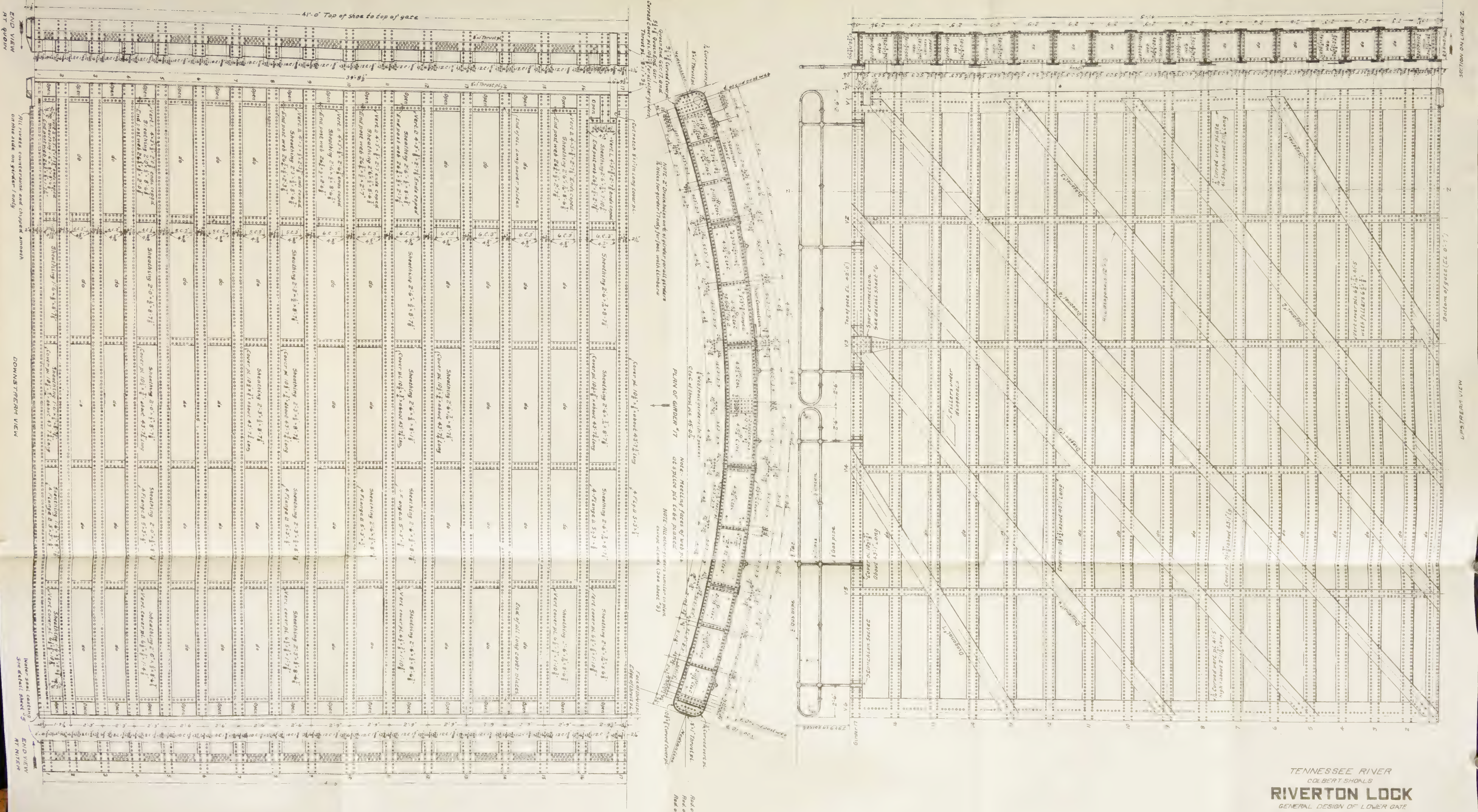

SECTION
Scale of Feet
PLAN
X Leaf
Y Leaf
Idler
12 Steps - 13¾" tread, 9¾" rise
1" Radius
2 Washer Bars
40 Bolts
40 Anchor Bolts 12" c to c
16 Holes
2" Crane Chain
45° Slope
Broken stone & gravel well packed
GENERAL LAYOUT
Scale of Feet
TENNESSEE
RIVER
Concrete Wall
Approx. N
PLAN
Scale of Feet For Plan, Sections A-A, BB, CC and Block
45° Slope
40 Anchor Bolts 12" c to c
16 holes
Inlet Culvert
Outlet Culvert
Valve
SECTION A-A & ELEVATION
Looking down stream
END VIEW OF BLOCK
Showing form of key
SECTION B-B
SECTION C-C

BEAR TRAP DRIFT SLUICE

COLBERT SHOALS CANAL

CONCRETE RIVER WALL AND FOUNDATION FOR BEAR TRAP


SECTION ON LINE Z-Z
Web
op
Diagonal
Stanchion Socket
7/16" Curved vert.pl.
8"x1" Thrust pl.
Median line
END VIEW AT QUOIN
on the side on gl


41'-0" Top of shoe to top of gate
END VIEW AT QUOIN
DOWNSTREAM VIEW
PLAN OF GIRDER #17
UPSTREAM VIEW
SECTION ON LINE Z-Z
END VIEW AT MITER

TENNESSEE RIVER
COLBERT SHOALS

RIVERTON LOCK

GENERAL DESIGN OF LOWER GATE
DESIGNED UNDER DIRECTION OF
MAJOR Wm. W. HARTS
CORPS OF ENGINEERS, U.S.A.
BY
JOHN M. G. WATT, ASSISTANT ENGINEER
E. H. JOHNSON DRAFTSMAN
SCALE 3/8" = 1 FT. — DECEMBER 10-1908

APPROVED
W. W. Harts
MAJOR CORPS OF ENGINEERS, U.S.A.

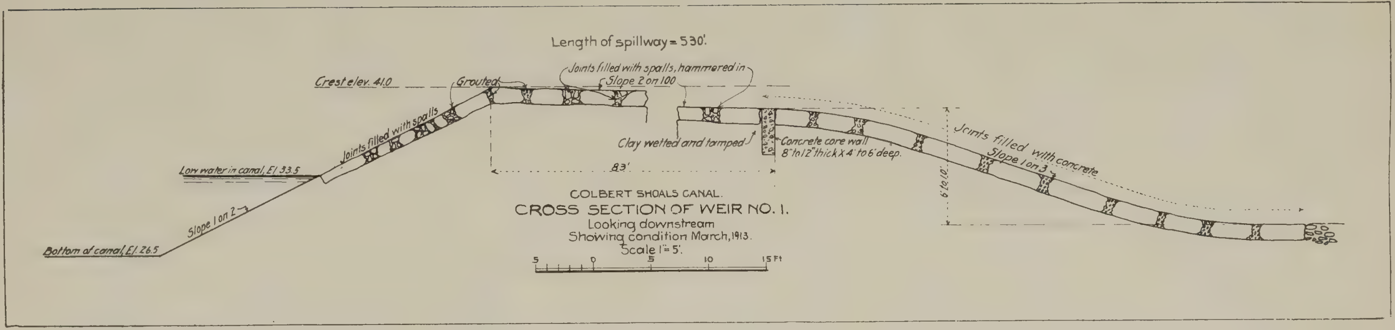

Length of spillway = 530'.
Crest elev. 41.0
Grouted
Joints filled with spalls, hammered in
Slope 2 on 100
Joints filled with spalls
Low water in canal, El. 33.5
Slope 1 on 2
Bottom of canal, El. 26.5
Clay wetted and tamped
Concrete core wall 8" to 12" thick X 4' to 6' deep.
83'
6' to 10'
Joints filled with concrete
Slope 1 on 3
COLBERT SHOALS CANAL.
CROSS SECTION OF WEIR NO. 1.
Looking downstream
Showing condition March, 1913.
Scale 1" = 5'.
5
0
5
10
15 Ft

Fig. 12. (See pages 80-82.)

the side slopes are 1 on 2, and are unpaved, although paving was provided for in the approved project. It is assumed that the paving was omitted for reasons of economy. The excavated material was deposited on both banks of the cut, leaving berms 20 feet wide. The wasted material was irregularly deposited, as was most convenient during the excavation, and no effort was made to shape up the mounds; and the material on the river side forms an embankment for the canal from the lock to the head of the shore section, with minimum top elevation (near the lift lock) of 43.5 and with maximum elevation of 76.0. The profile along the top of this embankment may be seen on Plate III. Some growth has begun on this mound, of young trees and brush, but nevertheless the steep slopes have permitted considerable wash of the material back into the cut. There are four weirs: No. 4 near Ross Branch, No. 3 near Hayes Branch, No. 2 near Bledsoe Branch, and No. 1 at Chickasaw Branch. The proposed weir, No. 5 at Boones Branch, was for some reason omitted; and each of the weirs was given a length of only 200 feet, instead of 300 feet, as proposed in the approved plans. The crests of the weirs are at elevation 41.0. The weirs are simply paved places across the embankment of the canal, the pavement extending down the slope on canal side to elevation 37.0. The thirteen small tributaries of the canal enter under the roadway along the left bank of the canal, through concrete culverts or under concrete bridges, and drainage from the ditches along each berm passes down the slopes of the canal at intervals through tile or concrete-lined channels.

The lift lock is of masonry, the stone being in part sandstone and in part hard limestone. The extreme length is 550.5 feet; length between hollow quoins, 350 feet; and width of chamber, 80 feet. At extreme low water the lift is 26.4 feet; and at the stage when navigation is possible in the open river—that is, a 7-foot stage at the head of the canal, the lift varies from 11.5 feet to 15.5 feet. The top of the lock walls is at elevation 42.37 and of the bottom at 0.5; miter sills are at elevations 26.25 and 1.25, and depths on sills (based on the lowest stage of record) are 7.67 feet for the upper and 6.25 feet for the lower. The lock is filled through culverts in the walls, each 8½ by 10 feet, discharging through 3 by 3 foot openings at the bottom of the walls, there being eleven of these openings on each side. The culverts are closed by Stoney gates, 10.67 by 9.25 feet, operated by a gearing requiring nine complete turns of the levers for full opening. For some reason, which is by no means apparent, the culvert was so arranged that both the upper and lower Stoney gates are placed at the same level—that is, with bottoms at elevation 4.0. A cheaper and more easily operated upper valve would have been one raised about 20 feet above its present position. The miter gates are of steel, of the arched type, with skin on lower side, and having steel contacts at quoins and miter posts. Length measured on chord is 45.04 feet and on curve is 45.94 feet. At the lower end of the lock there is a pair of guard gates, to be used when it is desired to unwater the lock, of the same type and construction as the main gates. The height of the upper gates is 16.12 feet, of the lower 41.12 feet, and of the guard gates 32.25 feet. Each leaf of the upper gates weighs about 31.5 tons, of the lower about 80 tons, and of the guard gates about 62.5 tons. The lock gates are operated by hand-power capstans, acting by rack-and-pinion on a gate arm attached to the gate 18.75 feet from the quoin. There are no approach walls at the upper end of the lock, but at the lower end there are masonry approach walls on both sides of the entrance, each with top at elevation 33.0. The land approach wall is 475 feet long and the river wall 185.5 feet. The excavation for the lower approach to the lock extends for 785 feet below the lower end of the lock. From the head of the canal to the lower end of the excavated lower approach the total distance is 42,565 feet, or 8.06 miles.

QUANTITIES.

The following quantities represent the totals for the completed canal. Masonry in lock, 29,289 cubic yards, and in approach walls, 9,088 cubic yards; concrete in canal wall, 30,898 cubic yards, and in minor structures, 475 cubic yards; rock excavation in canal, 151,282 cubic yards; in lower approach, 10,266 cubic yards, and for lock, 16,000 cubic yards; excavation of hardpan in canal, 383,105 cubic yards; earth excavation in canal, 1,903,302 cubic yards; in lower approach, 74,828 cubic yards, and for lock, 101,000 cubic yards; backfill for lock, 12,015 cubic yards, and fill in mounds, 60,000 cubic yards; pavement on lock terreplein and at the four weirs, about 900 square yards; steel in gates and anchorages, 392 tons; in valves and operating machinery, about 106 tons, and in bear-trap gate, about 17 tons; timber in bear-trap about 6,000 feet board measure. The total amount of excavation was about 2,640,000 cubic yards; of backfill and fill in mounds, about 72,000 cubic yards; of masonry and concrete, about 69,750 cubic yards; of steel, about 555 tons; and of timber, about 6,000 feet board measure. In addition, there were constructed two lock houses and one tool house of brick, and several wooden outhouses, at a total cost of about $13,500.

APPROPRIATIONS AND EXPENDITURES.

The allotments for the construction of the canal from the appropriations for the middle section of the Tennessee River were as follows:

September, 1890	$150,000.00
July, 1892	300,000.00
August, 1894	245,000.00
March, 1899	100,000.00
June, 1902	200,000.00
March, 1903	350,000.00
March, 1905	250,000.00
June, 1906	100,000.00
March, 1907	300,000.00
March, 1908	93,000.00
March, 1909	120,000.00
June, 1910	100,000.00
From other sources	14,118.50
Total	$2,322,118.50

The total amount allotted was $2,322,118.50; and the cost of the canal up to the date of opening on December 14, 1911, was $2,309,885.50, since which date the remainder of the appropriation has been expended for the purchase of additional ground and for the extension of the weirs.

ACCIDENTS SHORTLY BEFORE COMPLETION OF CANAL.

During the excavation of the shore section of the canal there was left by the contractor an earth dam across the head of the excavation, just below the end of the concrete wall; and the old channel of Chickasaw Branch, near the lock, was left open to drain the excavation. On January 3, 1911, when the new fill across this drainage channel had just been completed the earth cofferdam at the head of the excavation gave way during a sudden rise in the river. The canal filled rapidly, and the new embankment at Chickasaw Branch washed out, permitting flow through the embankment and out into the river. Fortunately, this opening was quickly closed without material damage to the canal slopes, and the cost of repairing the damage was inconsiderable.

While the earth cofferdam was still in place, the high water of April, 1911, occurred, reaching an elevation of 50.4 at the head of the canal and 45.0 below the lock, and remaining in flood stage for a considerable period. During this flood the water flowed into the canal over weir 4 and over a short reach of unprotected embankment just above the weir. Scour over this low place in the embankment caused a breach, which extended into and carried away part of the weir paving. Shortly after this breach was formed water began flowing around the end of the earth cofferdam, speedily breaching that dam and causing a swift current into the canal and out again through the breach at weir 4, enlarging the breach to a width of 120 feet. The swift current caused considerable damage to the canal slopes and scoured the canal bottom, and the channel from the canal to the river to a depth of 12 to 15 feet below canal bottom. The breach in the cofferdam was closed during continuance of high water, but with considerable difficulty because of swift current. Large rock were dumped from barges into the opening until the flow was considerably reduced, and the voids were then gradually filled by small stone and earth, and the cofferdam was then completely restored. During the following low water season the breach at weir 4 was filled and the pavement was restored. During the same high water a small breach also occurred at weir No. 2, but it was not extensive and the damage was inconsiderable. In restoring the cofferdam there was used 6,100 cubic yards of rock and earth, and in repairing the breaches at weirs 2 and 4 about 20,000 cubic yards of fill were placed and 630 cubic yards of rock were used for paving.

HIGH WATER SLOPES IN CANAL COMPARED WITH CALCULATIONS.

It was noted during the time of the break in the cofferdam in April, 1911, that when the water reached the tops of the lock gates water level just below the gates was about 3 feet lower, and this fact caused some uneasiness because of the possible danger from a flow of water under this head over the low ground between the lock mound and the high bank of the river. On December 30, 1911, after the removal of the cofferdam at the head of the canal the gates were again topped, and at that time the difference in level between the water above and below the lock was 5½ feet. The crest of this rise occurred two days later, at which time the water just above the gates was at 42.6 and just below at 39.4. The calculations referred to on page 77 indicated that there would be practically no fall over the gates at the time of submergence, and that the slope in the canal would then be practically the same as in the open river, and therefore that there would be no danger in permitting flow over the unpaved terreplein of the lock and over the low ground to the left of the lock mound. The recommendation for the omission of the guard lock was made to depend very largely on the results of these calculations as to the probable slopes in the canal at high water; but, as shown by the observations just mentioned, the slope in the canal at the epoch of submergence is very far from being the same as in the open river. While the original calculations are not on file, it is believed that the usual formulas were applied; and it is very likely that the formulas have failed to give correct results because of incorrect assumptions as to the constants depending on roughness of channel. It seems that the weirs do not discharge nearly so much water per linear foot of crest as was anticipated, and that the carrying capacity of the canal is greater than indicated by the calculations. It is true that the aggregate lengths of the four lower weirs was only 800 instead of the 1,500 feet used in the calculations, but this does not explain the matter as will be seen by noting the observations as to slopes mentioned on pages 86 and 87. The weirs, instead of having sharp crests, are quite wide on top and have rather rough top surfaces, and the waterways from the weirs to the river are more or less obstructed. On the other hand, the concrete weir is longer than was originally planned, has a narrow crest, and discharges freely into the open river, and yet it discharges very much less water per linear foot than was expected. From page 77 it may be noted that it was expected that this weir would be discharging *all* of the water entering the head of the canal until the river at the head had reached elevation 44.5, and that the water surface in the lower section of the canal would then be at elevation 41.0. Actually, when the elevation at the head was only 44.5, all of the weirs were discharging, and the canal level at the lock gates was about 41.5. From page 77 it may be noted also that the lock gates were not expected to be topped until the river at the head of the canal had reached elevation 48.0, while actually they were submerged when the elevation at the head was 45.0.

After the changes in lengths of weirs 1, 2, and 4, mentioned hereafter,there were several high waters which topped the lock gates. On March 20, 1913, at the epoch of submergence of lock gates the fall over the gates was 4.2 feet, the river at the head of the canal then being at elevation 44.8. This rise crested two days later, at which time the water surface at the head of the canal was at elevation 45.9, above the gates at elevation 42.4 and below the gates at 38.6. On April 2, 1913, the canal surface reached just to the top of the lock gates; the elevations of the water surface then being 42.0 above the gates and 37.0 below. Two days later the river rose slightly, and at the crest of the rise the elevations were 45.7 at the head of the canal, 42.3 above the gates, and 38.0 below. While the observations are too few in number to permit any definite statements, there is an indication that the increase in length of the weirs has reduced to a slight extent the fall over the lock gates at the time of submergence; but that the fall remains too great to safely permit a flow over the low ground to the left of the mounds or over any unpaved fill in the terreplein of the lock.

To show the conditions as to the slopes in the canal at stages which do not top the gates, the following observations made at various times in 1913 are given: January 10, about 9 a. m., water surface below gates at elevation 32.0; above the gates at 41.6; at weirs 1, 2, 3, and 4 at 41.6; at foot of concrete weir, 41.8; at head of concrete weir, 41.9; and 42.4 at head of canal. January 30, about 8 a. m., 36.9 below gates, 41.9 above gates, 41.9 and 42.0 at foot and head of weir No. 1; 42.0 at weirs Nos. 2 and 3; 42.1 at weir No. 4; 42.4 and 42.55 at foot and head of concrete weir, and 44.6 at head of canal. March 14, about 2.30 p. m., 28.1 below gates; 41.2 above gates; 41.2 at weirs 1, 2, and 3; 41.25 and 41.3 at foot and head of weir No. 4; 41.35 and 41.4 at foot and head of concrete weir; and 41.4 at head of canal. March 16, about 10.30 a. m., 35.0 below gates, 41.7 above gates, 41.7 at weir No. 1, 41.8 at weir No. 2, 41.85 at weir No. 3, 41.85 at weir No. 4, 42.0 and 42.2 at foot and head of concrete weir; no record for head of canal. These observations show the very slight differences in depth of overflowing water at head and foot of the mile-long concrete weir.

Changes Made in Canal Since December 14, 1911.

The failure of the weirs to give the slope expected in the canal at the epoch of submergence of gates, and the consequent unexpected fall over the gates when they were topped, caused the assistant in local charge to recommend an extension in lengths of the weirs, and three of them were extended in 1912. The present lengths are 530 feet for weir No. 1, 420 feet for weir No. 2, 200 feet for weir No. 3, and 330 feet for weir No. 4. No attempt was made to select a definite length for the weirs, it being ordered that each of them should be extended as far as practicable without requiring extensive excavation of the high spoil bank, and the resulting lengths were as stated. In the extension of the three weirs additional paving of about 15,000 square yards was required, of which about 6,800 square yards was grouted. A more direct channel was cut from weir No. 1 to the river, as the flow from this weir through the old channel of Chickasaw Branch was causing a dangerous cutting near the canal bank, and considerable paving was required for this new channel (included in total stated). Nothing has been done toward extending weir No. 3, as the spoil bank is very high at both ends of this weir and the extension would require considerable excavation. It is proposed to improve the discharging capacity of this weir by removal of the vegetation and the lowering by scrapers of the surface of the ground in its front. It should be noted that this weir was not placed opposite the small channel of Hayes Branch, and that the water discharged over this weir must pass across the old fields, the surface elevation of which, opposite this weir, being from 41.0 to 42.0. The effect obtained from the increase in length of the weirs is not sufficiently important to warrant any further extension, which could be done only at a considerable expense for excavation and paving.

Since the head at the lock gates at the epoch of submergence can not be reduced to a negligible quantity by an extension of the weirs, it has been decided to make safe those parts of the canal which might be endangered by this excessive head. The bank of the canal on the land side for about 800 feet above the lock was left at elevation 42.0 to 42.5, which was the natural surface of the ground, and a short distance back from the canal there is a low swale leading back of the lock mounds to the river bank at a considerable distance below. Outflow begins, therefore, over this part of the canal bank at the same time that the gates are topped, and the fall of the water to the low ground in rear is 4 to 5 feet. Some erosion was noted during the overflows in 1911 and 1912, and it was feared that the canal might eventually be threatened because of such scour. For these reasons this part of the canal bank is being raised, forming what is essentially a levee, to connect the lock mound with the high bank of the river. At present it has been raised to about elevation 45.0, but it will be raised somewhat further, although the exact elevation to which the levee is to be carried has not yet been decided. Very likely it will be carried only to a sufficient height to prevent its being topped at ordinary high water, since the fall at extreme floods over this levee will not seriously endanger the canal. The material for the levee is being obtained by a clam-shell dredge from the trunk of the canal, which is being widened for that purpose. The widening would have been required in any event, even though it had been necessary to waste the material; there being two important reasons for giving greater width to the canal just above the lock—one to provide a mooring place for boats awaiting lockage and for Government boats, and the other to prevent the wave caused in the canal by the filling of the lock. With the narrow canal as constructed the filling of the lock caused a drawing down of the water surface at the lock of more than a foot, setting up a current toward the lock, the checking of which caused a wave to pass back up the canal. So far, the basin has been widened to an average bottom width of about 125 feet for a distance of 800 feet above the lock, and there has already been noted a considerable lessening of the amount of the draw-down at the lock due to the filling, and of the height of the reverse wave. The considerable head at the time of topping of the gates not only threatened dangerous scour over the low place in the canal bank, but also threatened scour over the backfill forming the terreplein of the lock, none of which was paved. This danger has been largely removed by the raising of this fill to elevation 45.0. By the time the water has reached this elevation the head will have been considerably reduced, and it is believed that a thick sod will then protect it from erosion; otherwise the terreplein will be paved throughout. The scouring effect of the overflowing water has been reduced, also, by leaving the lower gates open, instead of closed, as was done at first. With the lower gates closed, the spillway length over the lock is from the foot of the mound on one side to the foot of the other mound, whereas by leaving the lower gates open the water flows into the lock chamber over the upper gates and along the whole length of both walls, giving a considerably greater length of spillway. Of course, at much higher stages the effective length of spillway should probably be measured at right angles to the flow, but at such stages the head will be so much reduced that there will not be great danger of scour.

The weirs are paved with large flat stones, placed by derrick, and the interstices are carefully packed with smaller stones and spalls, rammers being used so as to make the packing compact; but the surface is not sufficiently tight to prevent water passing through it. In several instances a flow has been established on the surface of the earth just beneath the paving, causing scour and a falling-in of the paving. At weirs 1 and 2, where these troubles have occurred, an attempt has been made to prevent this flow underneath the paving by the use of a concrete cut-off wall, as shown in the section of weir No. 1, given in Plate VII. It will be seen that the concrete wall extends several feet into the earth embankment, and that the weir paving between the wall and the river edge of the weir is well grouted, and that the wall and the grouted stone paving form a sort of dam at the outer edge of the weir. It is believed that this cut-off will prevent the underflow and the consequent falling-in of the paving. A more certain means of correcting the difficulty might have been devised, but the plan selected was rather inexpensive, and a more elaborate one can be adopted later if found to be necessary. As stated heretofore, the slopes of the canal were not paved as provided for in the approved project. Some washing of the slopes by the waves of passing boats, by rain water, and more especially by the swift currents at the time of the two breaches described above, has been noted, and in a few places where the scour has been more marked a little paving has been placed. This paving extends 1 foot below low water surface and about 3 feet above. It is very likely that a considerable extension of the paving of slopes will have to be done in the future, but it will be done gradually, as the need for it at special points becomes apparent.

The operation of the Stoney gates as well as the lock gates was planned to be done by either pneumatic or electrical machinery, and the ratio of the gears was determined accordingly. No especial difficulty has been encountered in operating the lock gates, but for the valves six to eight men were required to open them. In order to reduce the power required for opening the valves a new gear has recently been installed, and now three men are needed at each valve and nineteen turns are required for complete opening, whereas with the original gear six to eight men opened the valves with only nine turns of the levers. There is no immediate intention of arranging for power operation of the gates and valves, but as soon as the navigation through this lock becomes considerable such installation will be required. While plans have not been definitely adopted for the power operation, it is likely that compressed air will be used and that the compressor will be operated by a turbine water wheel.

In a report in 1910 on the general subject of the improvement of the Tennessee River, the district officer stated: "No provision has been made for a guard lock for this canal, as it is not yet known positively that such a lock will be found necessary. Experience at other canals indicates that sooner or later a guard lock will be needed to protect the canal from drift at high-water stages and enable it to be drained when necessary. Such a lock, if built of concrete, could likely be installed for $300,000, on the basis of present costs. A concrete sluiceway near the Riverton lock, closed with Stoney gates, will also doubtless be needed before many years in connection with the guard lock to drain the canal prism for the purpose of making repairs or stopping leaks. Such a sluiceway, with a 50-foot opening, would cost about $100,000, including gates.'' The same district officer in his annual report for 1911, after describing the breaches caused by the high waters of January and April of that year, stated: ''These experiences emphasize the danger to which the canal will be subjected at times of high water after the earth cofferdam at the head of the bank excavation has been entirely removed, and strongly indicate the need of some sort of guard lock such as the original plans called for. No simple cofferdam or temporary structure would be sufficient to check the flow and protect the canal banks in case a breach in the embankment should occur after the canal has been opened to traffic. This subject should be studied to determine whether a guard lock and some modifications of the side levees are not necessary to insure protection at the highest stages.''

The United States employee who has been in local charge of the canal for several years, while believing that the addition of a guard lock would be the best solution of the difficulty, in that it would considerably reduce the chances of breaching the embankments, thinks that an emergency dam at the head of the shore section of the canal, to be used in case of breaks in the embankment, will solve the difficulty. He proposes concrete abutments 80 feet apart, and a movable dam of the needle or of the Boulé type. This dam would be used only in the event of a break, or of a need for draining the canal. Such an emergency dam would interfere less with traffic than would a guard lock, would cost much less for construction and for operation, would prevent any great extension of damage from a breach in the canal embankment, would make easy of repair such breaks if they occur, and would provide for drainage of the canal when necessary. On the other hand, it would not be effective, as would a guard lock, in minimizing the chances for a breach of the embankment, nor would it prevent drift from entering the canal.

In order to arrive at an answer to the question whether a guard lock is necessary or desirable, the reasons urged for the construction of such a lock should be noted. The most important reason seems to be the reducing of the danger of breaks in the canal embankment, and the next most important the lessening of the extent of damage from breaks and the easier repair of damage. The lesser important reasons are the provision for draining the canal and the lessening of trouble from drift. Taking up first these less important advantages, it may be stated that the necessity for draining the canal will be extremely rare, and possibly may never occur. When it does become necessary it can be provided for by a cofferdam near the head of the shore section and by an installation of pumps. If it was likely that drainage of the canal would frequently be necessary, guard gates or other structures at the head might be justified, but the cost of these and the probable infrequent need of draining the canal together make it appear to be inadvisable to provide such structures unless needed for other reasons. As to the question of drift, this has been discussed above on page 72, and all that is necessary now is to say that the conclusions stated in that paragraph seem fully to be justified by actual experience. The important fact of the reducing of the probability of breaching of the canal embankment by the construction of a guard lock would alone justify its construction if there was no other way to make the canal reasonably safe. While the guard lock would practically eliminate the danger of breaching at stages below that which submerges the guard lock, the danger would still exist when the river rose sufficiently to cause an overtopping of the gates and walls of that lock, after which there would be a current through the canal. The fact has been mentioned above that the slopes in the canal at high water have not been what were anticipated; that at the epoch of submergence of the lift lock gates there is a considerable fall over them; and that there is a considerable fall over the weirs when they begin discharging, as well as over the low ground between the lock mound and the high bank. Since the danger of scour on the terreplein of the lock has been nearly eliminated by raising the elevation of the earth fill (and can be entirely eliminated by paving), it is not seen how this greater head can endanger the lock. The danger of scour over the low ground between the lock mound and the high bank will be removed by the construction of the proposed levee connecting the mound with the bank. Now, if the weirs are made entirely safe it is difficult to understand where there is any considerable danger remaining to the canal due to the unexpectedly greater head for the discharge over the lock and spillways. Undoubtedly, these weirs can be made safe at much less expense than would be necessary to construct a guard lock, and these weirs would nevertheless have to be strengthened even though a guard lock were constructed. With a guard lock the canal trunk would have to be filled by water entering over these weirs, which filling would begin under a considerable head, unless the trunk was gradually filled through the valves of the guard lock. Of course, however secure the weirs may be made, it is still possible that breaks in the canal may occur, and if there is a guard lock the damages from such possible breaks will be reduced and their repair will be made easier and cheaper. I do not believe, however, that the mere possibility of such breaks will warrant the inconvenience of a guard lock and its cost of construction and of operation. But work on the weirs should be continued until they are made safe, and all embankment subject to a cross current under any considerable head should be thoroughly and well paved. While an emergency dam at the head of the shore section of the canal would not greatly interfere with navigation, would not be very expensive for construction, nor for care and operation, I do not believe that it is necessary at the present time to provide for such a structure. It would be better to use the funds now available to make the canal reasonably safe against breaching, rather than to construct a dam to be used only in case of an accident to the canal. A few years experience with the operation of the canal may, nevertheless, indicate that some structure will be needed for the purpose of stopping the flow through the canal in case of a break, but the expense of building such a structure does not now seem to be justified.

While a guard lock appears to me to be unnecessary for the safety or convenience of operation of the canal, I believe that it would have been an excellent plan to construct such a lock in connection with a cross dam at the head of Colbert Shoals, in order to improve by canalization the 21 miles of river between the canal and the foot of the Muscle Shoals section. From the Florence bridge, which is at the foot of the Muscle Shoals, to the head of the Colbert Canal the fall at low water is 13 feet, and a dam at the head of the canal raising the water level 15 ft. would give slackwater navigation of 6-ft. minimum depth to the bridge. The estimated cost of excavating channels 150 feet wide and with extreme low water depth of 6 feet in this 21 miles was placed by the district officer at $800,000. No estimate has been prepared for the suggested lock and dam at the head of the canal, but it is thought that they could be constructed for not more than $1,500,000, including flowage damages. As offsetting the cost of the slackwater improvement, the cost of the open channel improvement should be added to the estimated cost of the guard lock (assuming that it is necessary for the protection of the canal), and the total of the ''off-setting'' is therefore about $1,100,000. The superiority of the slackwater improvement over that by open channel methods is very marked, both as to ease of navigation and as to development of terminal facilities; and, in addition, the dam at the head of the shoals would make possible the utilization of a considerable electrical power, amounting at low water to 13,000 to 14,000 horsepower at the switchboard. It is true that there is now no market in this vicinity for the power, in view of the fact that only a small part of it would be ''primary'' power (the maximum being available about 10 to 11 months per year); but within a comparatively short period it is believed that such power would be of considerable value. Unfortunately, however, this slackwater improvement can not now be adopted, as the work on the improvement by regulation has advanced too far to make it advisable to change the method of improvement, and the question of constructing a guard lock at the head of Colbert Shoals must, therefore, depend entirely on its necessity as a protection for the canal.

CHANGES IN CANAL PLANS WHICH MIGHT ADVANTAGEOUSLY HAVE BEEN MADE PRIOR TO CONSTRUCTION.

In the light of the experience with the canal since its completion, it might be interesting to consider what changes might have been made in the plans for securing greater safety to the canal or greater convenience of navigation. The writer eliminates the guard lock from consideration, as he believes it to be unnecessary except in connection with the slackwater improvement of the section of river just above the Colbert Shoals; nor does he suggest any change in the river section of the canal itself. For the shore section, however, it appears to him that there would have been a considerable improvement in design if the canal had been arranged so as to entirely prohibit any flow of water through it, and so as not to have this section of the canal submergible at *ordinary* high water. To accomplish these results there should be a pair of guard gates installed at the lift lock, with tops above extreme high water, and with their abutments connected by earth levees to the high bank of the river on the one side and to the canal embankment on the other. The tops of these levees should be at least 3 feet above extreme high water, and be 12 feet wide on top with side slopes of 1 on 3, the tops and slopes being well sodded or paved. The river levee should run at right angles to the axis of the lock for about 50 feet, and should be continued along the canal bank at full height for at least 100 feet above the upper end of the lock. The river embankment should begin at the upper end of the shore section of the canal and be continued to a junction with the levee just described, and its top should be above ordinary high water and should be so graded in height that it will be flooded progressively, as the river rises, from the upper to the lower end. An examination of the gage records indicates that the elevation of the top of this embankment at its upper end should be at about 49.0, which would put it above all, except four high waters in the twenty-three years in which gage records have been kept. A greater elevation might be somewhat better, but the cost of such increase hardly seems to be justified. From the upper to the lower end the grade of the top of the embankment should rise to 50.0, as this increase would be sufficient to insure the progressive submergence necessary to prevent any cross flow over the top of the embankment. The thickness of this embankment at the top should be not less than 8 feet, with side slopes of 1 on 3. While a good sod would probably protect the slopes of this embankment from wave wash during the short periods of high water, it would be safer to pave it with light riprap on the river slope and across the top. The material excavated from the trunk of the canal would be more than sufficient for the construction of this embankment, except at the lower end, for which portion some of the excavated material would require longitudinal transportation in order to put it into the embankment. At the upper end the excess material could be wasted on the land side of the canal, or it could be used to give greater width to the river embankment of the canal, but *not* greater height. There would be no weirs in this canal, and the flood water must therefore pass out of the upper end of the canal. On page 72 it is stated that the calculations indicate that the currents resulting from the discharge from this tributary area would not be obstructive to navigation and would not cause dangerous erosion of slopes. There might be some slight interference at rare intervals, when, with the canal in service and its level near to the top of the main lock gates, a sudden discharge from the tributary area might cause a temporary increase in height of canal level sufficiently to top the gates before the guard gates could be closed. This occurrence would be so rare, and the conditions would continue for such a short period, that it would hardly be necessary to make any provisions to eliminate the possibility. A canal constructed according to the plan suggested would be usable up to the stage when navigation in the open river became easy, and the tops of the main gates of the lock should be given the height necessary to permit this. The present elevation of tops of 42.0 is undoubtedly sufficiently high. The guard gates would be closed whenever the canal surface rose to within a few inches of the tops of the main gates, and would be again opened when it had fallen to a few inches below this elevation. With guard gates closed, the canal would, of course, be out of service. From the head of the canal to the foot of the concrete wall there would be the same amount of deposit and the same amount of drift under the proposed plans as for the canal actually constructed; but within the shore section the proposed canal would have less drift and much less deposit. The flow over the weirs and over the lock of the present canal causes deposit throughout the length of the canal, and especially just below each of the weirs and just above the lock gates, whereas in the canal suggested there would not be this flow through the canal with its consequent deposit. At extreme floods the embankments would be submerged when the river, and the canal surface at the same time, rose at any time to the level of the top of the embankment, and as the canal and river levels would then be the same at the point of submergence there would be no head to cause a current across the top of the embankment. The submergence would begin when the river at Shades Branch rose to 49.0, corresponding to a river elevation at the head of the canal of from 50.0 to 50.5. At extreme flood, after the entire canal embankment had become submerged, the canal would form part of the high water channel of the river, and since the levees and guard gates at the lock would prevent flow past them there would be a slight head established across the lower end of the canal embankment from the canal toward the river, but if the top of the embankment was well sodded or paved with riprap no damage could be caused by this small difference in level.

OPERATION OF THE CANAL.

The canal was opened to navigation on December 14, 1911, and between that date and June 30, 1913, there has been an aggregate of only 212 lockages, exclusive of Government craft, or fewer than 12 per month. The total freight carried through the canal in the 18½ months was 56,188 tons; but it should be noted that the usefulness of this canal can not be determined until the lower river is improved so as to make possible a low water navigation, nor until the improvement between the head of the canal and Florence (now under way) is completed. The only permanent lock force so far employed consists of one lock-master and an assistant; but there has been a considerable force constantly at the canal for making repairs and certain betterments. It will be several years before the repairs and betterments have been completed, and before the force retained at the canal has been reducd to a permanent basis. It is expected that the permanent force will consist of only three lock-men until the business of lockage has increased to considerable proportions, and that the necessary dredging will be done by the fleet belonging to the general Tennessee River improvement. On account of the somewhat inadequate cost-keeping records it is very difficult to state what has been the cost for operation, what for repairs, and what for betterments. The annual reports of the district officer for 1913 give the following details as to costs:

Item.	December 14, 1911 to June 30, 1912.	Fiscal Year 1912–1913.
Nashville office and administration	$1,217.67	$1,353.26
Maintenance and operation of lock	1,973.05	3,942.97
Maintenance of canal trunk and embankment	7,980.88	22,837.55
Maintenance of buildings and grounds	873.65	1,834.49
Maintenance of floating plant	951.72	1,704.92
Miscellaneous and contingencies	579.53	2,826.81
Total	$13,576.50	$34.500.00

It will be seen therefore that in addition to the total appropriations of $2,322,118.50, made for the construction of this canal, an amount of $48,076.50 has been expended from allotments (under the terms of the general act providing for operating and care), for the maintenance and operation of the canal. As stated above, the exact amount expended for betterments can not be given, but it is roughly estimated that it was approximately $17,881.50, and that the sum of $30,195 was expended for repairs and for operating the canal. The total cost of the canal to date, including construction and betterments, may therefore be placed at about $2,340,000.

After a few years experience in operating the canal it will be possible to obtain some idea of what quantity of deposit in the canal may be expected to occur during each high water season. The records now available are sufficient only to give an indication that such annual deposit will not be extensive. In the past two years there has been dredged from the river section of the canal near the end of the concrete wall a total of about 10,000 cubic yards; but this deposit has been accumulating since this section of the canal was opened to the river in the early part of 1909, so that it is the combined deposit of more than four high water seasons. There is some additional deposit in this section of the canal, but it is nowhere sufficiently deep to warrant its removal. Before the shore section of the canal was filled in November, 1911, the trunk of the canal was cleaned, and the bottom was then nowhere above grade. In the two high water seasons the deposit has not been sufficient at any point to make dredging necessary, except that the canal was dredged to below grade just below the lock gates, in connection with the work of widening the canal there, but the deposit then removed constituted a very small part of the total of 12,000 cubic yards handled. From the lock chamber and the lower approach there was removed, in the fiscal year 1911-1912, 14,000 cubic yards of material, accumulated during a number of high water seasons; and in 1913 the deposit removed from the lock and approach amounted to 1,600 cubic yards, representing the actual deposit during the high water season of 1912-1913.

The bear-trap closing the drift chute has been out of service during both the 1912 and 1913 high-water seasons, and its repair has been delayed pending completion of more important work. In the meantime drift entering the canal has been handled by a derrick boat, lifting the drift over the concrete wall or on to the banks of the canal, where it is dried and burned. The amount of drift has not been great, but would have been sufficient to cause inconvenience had it not been removed. It is expected to repair the bear-trap dam at an early date.

PERSONNEL.

The following is the list of district officers who have been in charge of the improvement of this section of the Tennessee River and of the construction and operation of the canal:

Maj. G. Weitzel, Corps of Engineers, ——, 1868, to May 24, 1871.

Maj. W. McFarland, Corps of Engineers, May 24, 1871, to May 15, 1876.

Capt. W. R. King, Corps of Engineers, May 15, 1876, to March 20, 1886.

Lt. Col. J. W. Barlow, Corps of Engineers, March 20, 1886, to March 18, 1891.

1st Lt. G. W. Goethals, Corps of Engineers, March 18, 1891, to December 20, 1894.

Capt. T. A. Bingham, Corps of Engineers, December 20, 1894, to July 10, 1895.

1st Lt. J. F. McIndoe, Corps of Engineers, July 10 to November 21, 1895; temporary.

Capt. Dan C. Kingman, Corps of Engineers, November 21, 1895, to May 2, 1901.

Maj. J. G. D. Knight, Corps of Engineers, May 2, 1901, to April 25, 1903.

Capt. W. J. Barden, Corps of Engineers, April 25, 1903, to May 31, 1904.

Maj. H. C. Newcomer, Corps of Engineers, May 31, 1904, to February 25, 1907.

1st Lt. W. G. Caples, Corps of Engineers, February 25 to June 18, 1907; temporary.

Maj. W. W. Harts, Corps of Engineers, June 18, 1907, to July 18, 1910.

Maj. C. A. F. Flagler, Corps of Engineers, July 18 to December 8, 1910; temporary.

Maj. W. W. Harts, Corps of Engineers, December 8, 1910, to July 24, 1911.

Maj. C. A. F. Flagler, Corps of Engineers, July 24 to October 21, 1911.

Maj. Edgar Jadwin, Corps of Engineers, October 21 to December 11, 1911.

Maj. H. Burgess, Corps of Engineers, December 11, 1911, to date.

The following assistants have been closely connected with the design and construction of the canal:

1st Lt. H. E. Waterman, Corps of Engineers, 1887-1889.
1st Lt. G. W. Goethals, Corps of Engineers, 1889-1891.
Asst. Engr. B. B. Smith, 1889-1891.
1st Lt. J. F. McIndoe, Corps of Engineers, 1894-1896.
Asst. Engr. S. B. Williamson, 1891-1896.
Asst. Engr. D. W. Church, 1895.
Asst. Engr. G. T. Nelles, 1896-1898.
Asst. Engr. W. S. Winn, 1898-1901.
Asst. Engr. J. M. G. Watt, 1902-1907.

Asst. Engr. C. A. Turrell, 1905-1908.
Capt. A. B. Putnam, Corps of Engineers, 1908.
Supt. C. E. Bright, 1908-1913.

The following boards of Engineer Officers of the Army were constituted to pass on various features of the plans for the canal:

Board of 1890: Lt. Col. J. W. Barlow, Maj. A. Mackenzie, and Maj. H. M. Adams.

Board of 1897 (on design for lower entrance for the canal): Capt. Dan C. Kingman, Capt. G. W. Goethals, and Capt. J. G. Warren.

Board of 1899: Maj. H. M. Adams, Maj. Dan C. Kingman, and Capt. H. F. Hodges.

Board of 1902: Col. Amos Stickney, Maj. C. McD. Townsend, and Capt. W. L. Sibert.

Board of 1905: Lt. Col. W. H. Bixby, Maj. G. A. Zinn, and Capt. H. Burgess.

In addition to the completion of the lift lock by hired labor, the increase in height of the walls of that lock was also done by the same method. A large quantity of stone for the proposed guard lock was quarried and dressed at the Keller quarry; the bear-trap gate was installed, and a considerable amount of work of minor character was also done by hired labor.

TABLE I. *River Stages at Riverton, Alabama.*

Table showing number of days each year that the river stood between successive foot marks on the gage from 1 to 25 feet. Gage readings are reduced to the gage in use from November 1, 1904, to October 1, 1908.

Year.	Below. 0	0 to 1	1.1 to 2	2.1 to 3	3.1 to 4	4.1 to 5	5.1 to 6	6.1 to 7	7.1 to 8	8.1 to 9	9.1 to 10	10.1 to 11	11.1 to 12	12.1 to 13	13.1 to 14	14.1 to 15	15.1 to 16	16.1 to 17	17.1 to 18	18.1 to 19	19.1 to 20	20.1 to 21	21.1 to 22	22.1 to 23	23.1 to 24	24.1 to 25	Over 25
1892.	0	0	17	22	17	28	31	25	27	30	25	18	21	15	8	15	14	3	6	3	1	3	3	0	4	2	28
1893.	0	0	2	40	64	54	23	21	32	10	13	9	13	9	13	6	6	4	0	3	3	2	0	4	2	5	27
1894.	0	4	64	46	55	45	35	26	7	7	6	11	19	10	10	0	3	1	2	1	1	1	1	1	0	1	8
1895.	0	0	55	41	39	30	20	21	13	25	22	18	16	8	6	6	6	9	5	4	1	3	2	1	2	1	11
1896.	0	0	33	34	49	42	34	50	25	13	11	7	7	7	6	7	1	3	2	3	6	6	4	2	2	0	12
1897.	0	39	48	8	27	47	34	16	16	13	10	8	11	7	8	7	3	6	1	3	0	3	3	3	3	2	39
1898.	0	0	0	23	23	77	58	46	28	19	13	10	8	11	7	5	8	2	3	3	4	1	2	5	7	2	0
1899.	0	43	54	43	19	24	13	11	5	10	21	17	13	5	2	5	7	5	1	2	0	4	6	4	6	4	41
1900.	0	0	9	47	36	36	32	24	29	9	16	18	16	13	14	10	8	6	9	2	9	3	3	3	0	5	8
1901.	0	0	0	46	18	25	19	38	29	14	29	20	18	10	10	4	8	4	6	6	4	3	6	6	4	5	33
1902.	0	0	68	34	41	24	21	12	17	20	19	15	10	14	5	2	2	4	5	5	2	0	1	2	3	0	39
1903.	0	21	75	14	15	32	36	19	15	11	6	13	11	6	5	4	5	6	6	1	1	6	2	4	4	2	45
1904.	22	53	15	54	47	42	31	26	13	11	14	11	2	6	3	5	0	0	2	0	0	1	1	1	0	1	5
1905.	0	0	41	21	49	22	44	25	31	25	23	17	10	9	5	9	6	2	3	5	1	3	2	1	2	1	8
1906.	0	0	0	0	20	29	38	50	39	33	32	33	19	11	7	9	13	2	4	2	5	3	2	4	2	1	7
1907.	0	0	10	27	49	31	21	45	48	22	26	12	11	12	10	7	3	3	3	8	4	4	1	2	3	3	0
1908.	0	0	0	0	0	0	0	0	24	27	44	40	25	9	34	20	10	18	17	24	18	13	7	1	7	4	24
1909.	0	0	32	36	27	21	20	24	8	18	20	14	17	21	19	10	8	3	13	7	3	3	4	2	6	8	21
1910.	0	0	39	30	50	26	38	37	32	24	15	11	19	5	11	7	10	6	2	1	2	0	0	0	0	0	0
1911.	0	0	23	54	47	26	50	27	14	14	18	9	6	5	4	6	2	3	3	2	2	1	1	2	0	3	43
1912.	0	0	22	46	18	26	41	30	23	22	17	8	8	8	7	5	7	5	7	12	0	4	3	4	5	5	33
Ave. .	1	8	29	32	34	33	30	27	23	18	19	15	13	9	9	7	6	4	5	5	3	3	3	2	3	3	21
Ave. total below	1	9	38	70	104	137	167	194	217	235	254	269	282	291	300	307	313	317	322	327	330	333	336	338	341	344	. . .

Tests of the Bangalore Torpedo

BY

Capt. F. B. WILBY
Corps of Engineers

The following description of the Bangalore torpedo is taken from the *Royal Engineers Journal* for March, 1913.

From the drawings (see Figs. 1-5, Pl. I) it will be seen that this is made in sections, the unit being a tin tube 6 feet 6 inches in length, and of 2½-inch diameter; all the units are absolutely interchangeable. One end of this tube is closed with a flat bottom (S), like that of a jam tin. The other end (T) is open and fitted with an external sleeve or socket projecting another 8 inches, into which (if desired) the closed (S) end of a similar tube can fit closely (see Fig. 1). A number of such unit tubes can thus be fitted together to any required length (see Fig. 2).

If dynamite cartridges (made up in packets of four abreast) are dropped into such a tube (which can be done very quickly), it will take twenty-three packets, or rather over 1¾ pounds to the foot run. Its explosive length is now 6 feet 6 inches, and this can be increased to 13 feet, 19 feet 6 inches, and so on by fitting together as many of these unit tubes as may be required. The closed end (S) of each tube butts tightly up against the explosive at the open end (T) of its predecessor. If the system is then fired from the last end left open, the whole will detonate, as the tin bottoms of the tubes offer no obstacle.

It has been stated that the 6 foot 6 inch tin tube is the unit of the system. To each unit, however, two other accessories are provided, to facilitate transport, placing and firing. These are "The Live Handle" (C, Figs. 1 and 5), and "The Nose" (B, Figs. 1 and 3). The former is provided, firstly to close the open end (T) of the tube during movement and prevent the explosive falling out; and secondly, to contain the means of ignition of the charge. (For reasons which will be evident later, *every* unit tube is provided with independent means of ignition). This handle is just a rough piece of dealwood, about a foot long, and of diameter sufficient to fit fairly closely into the sleeve or socket on the (T) end of the tube. In one end of it a recess is hollowed out with a chisel (Figs. 4 and 5), large enough to contain a single dynamite cartridge, with fuze and detonator in place, the latter being carried to the outside through

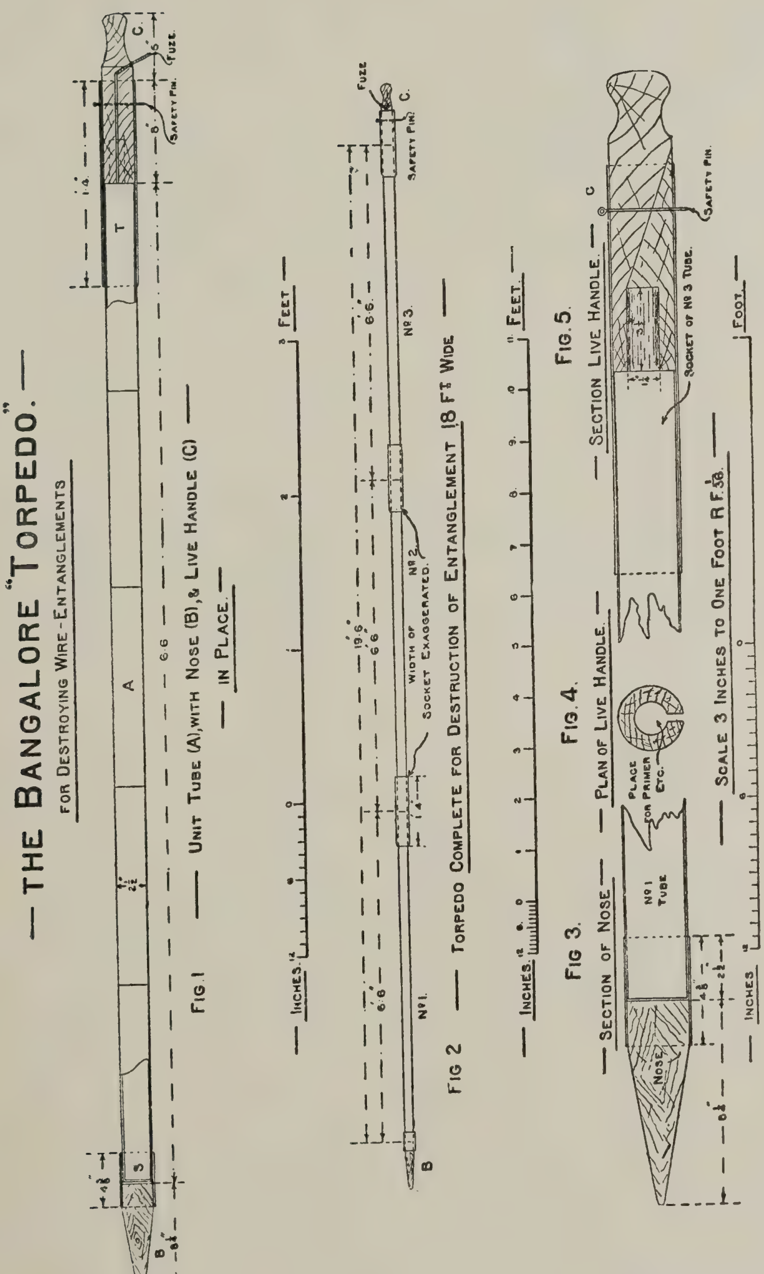

— THE BANGALORE "TORPEDO". —
FOR DESTROYING WIRE-ENTANGLEMENTS
FIG. 1 — UNIT TUBE (A), WITH NOSE (B), & LIVE HANDLE (C) — IN PLACE. —
A
T
S
B
C.
FUZE
SAFETY PIN
6·6
1·4
8"
5"
4⅝"
6¾"
2¼"
INCHES 12 6 0
FEET 1 2 3
FIG 2 — TORPEDO COMPLETE FOR DESTRUCTION OF ENTANGLEMENT 18 FT WIDE —
No 1.
No 2.
No 3.
19·6"
6·6"
1·4
WIDTH OF SOCKET EXAGGERATED.
FIG 3. — SECTION OF NOSE —
FIG. 4. — PLAN OF LIVE HANDLE —
FIG. 5. — SECTION LIVE HANDLE —
PLACE FOR PRIMER ETC.
No 1 TUBE
NOSE
SOCKET OF No 3 TUBE
SAFETY PIN.
C
INCHES 12 6 0 1 2 3 4 5 6 7 8 9 10 11 FEET
— SCALE 3 INCHES TO ONE FOOT R.F. 1/36. —
INCHES 12 6 0 FOOT

Plate I.

a groove in the wood. The other end of this cartridge, therefore, when the handle is in place, will press against the top of the explosive in the tube, and so serve to detonate it when itself fired by the fuze. A removable safety pin (large nail, or stiff piece of wire) which runs crosswise through the handle and socket, prevents the former from falling out during movement.

The ''Nose'' (Fig. 3) is a cone-shaped piece of wood fixed in the end of a tin socket a few inches in length, and just wide enough to fit over the (S) end of a unit tube. When thus fitted, the ''Nose'' enables the front end of the ''torpedo'' to force its way through the intricacies of a thick entanglement with greater ease than would the flat end of the unit tube. It can be pulled off and discarded in a moment. The weight of one unit tube (empty) with handle and nose is about 8½ pounds, when made of block tin.

* * * * * * *

In addition to the above extracts the article in the *Royal Engineers Journal* gives details of several tests of the Bangalore torpedo with the following general results:

TESTS.

''*1.75 pounds of dynamite per foot run, placed in this torpedo and the entire charge placed in the center of the entanglement, broke all wires, clearing a passageway 6 feet wide through the entire width of obstacle.* The effect was not so great if the torpedo was placed *on the ground* or *on top of the wires,* as it was when placed in *the center.*''

* * * * * * *

In order to test the efficiency of this torpedo, when used with our service explosive, ''rack-a-rock,'' three lengths of tin tubing were made, and turned over to me for test. They were the same as those described in the above article, except as to diameter of tube, which was increased from 2½ to 4 inches in order to accommodate the larger size sticks of rack-a-rock.

As there were only three 6 foot 6 inch lengths of tubing available, and as it was desired to test different strengths of charge, and different methods of placing, it was decided to make three tests on a 6-foot width of entanglement, rather than one test on an entanglement 18 feet wide as used in the English tests.

Accordingly, a high wire entanglement, 6 feet wide by about 30 feet long, was constructed for purposes of test. The posts were in two rows, and were mostly green locust, from 4 to 6 inches in diameter, from 5 to 7 feet long, and driven about 2 feet into the ground. A tight barbed-wire fence was built along each row of posts, and the space in between strung with the usual diagonals and

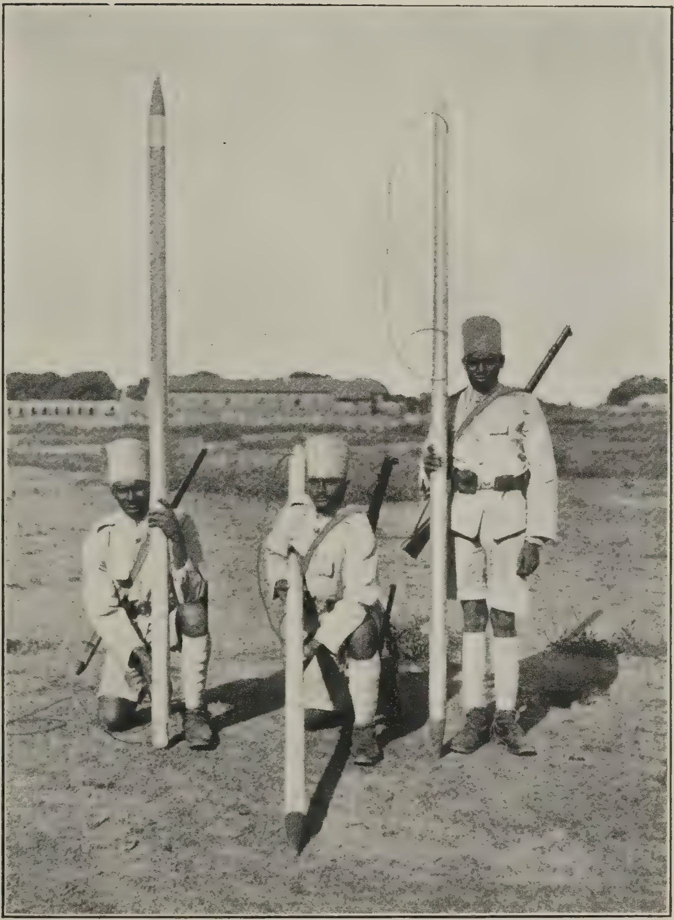


Fig. 1 (a). The Bangalore Torpedo, showing three interchangeable 6-foot 6-inch sections complete.

loose coils, all of the standard two-strand barbed wire. A view of this entanglement taken looking from end to end is shown in Fig. 1.

First Test.

a. Charge. Twenty-seven sticks of rack-a-rock, about 3½ pounds per foot, laid in the tube in a double chain, with the extra space tamped with clay. Five electric fuzes were placed at intervals of about 18 inches throughout the charge, with one more in the wooden base plug, all six being connected in series to the service magneto exploder.

b. Method of Placing. The torpedo was placed in the center of the wires as shown in Fig. 2, the nearest post being about 15 inches from the tube.

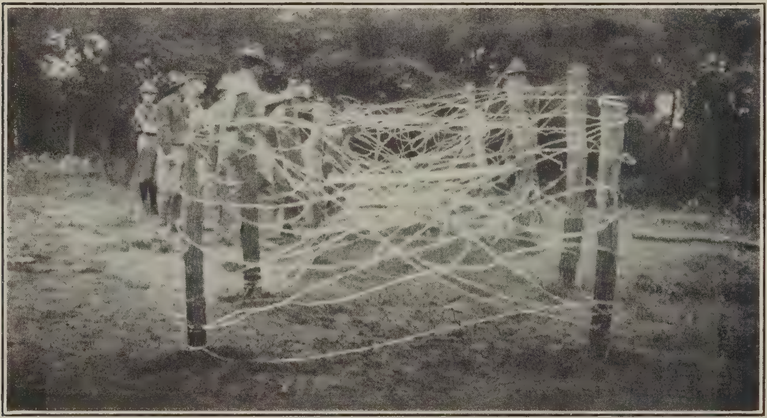


Fig. 1. Lengthwise view of entanglement.

c. Result. One wire was broken, otherwise the entanglement appeared to be unharmed. (See Fig. 3.) The poor result obtained is partly explained by the fact that from one-fifth to one-third of the charge did not explode.

Second Test.

a. Charge. Forty-five sticks of rack-a-rock, about 7 pounds per foot, laid in the tube in packages of four sticks, every other package containing an electric fuse, with one more fuse in the wooden base plug. In order to insure the explosion of the entire charge of rack-a-rock, each fuse was placed in contact with a priming charge of about 1 ounce of dry gun cotton. There were seven electric fuses in all, connected in series to the magneto exploder.

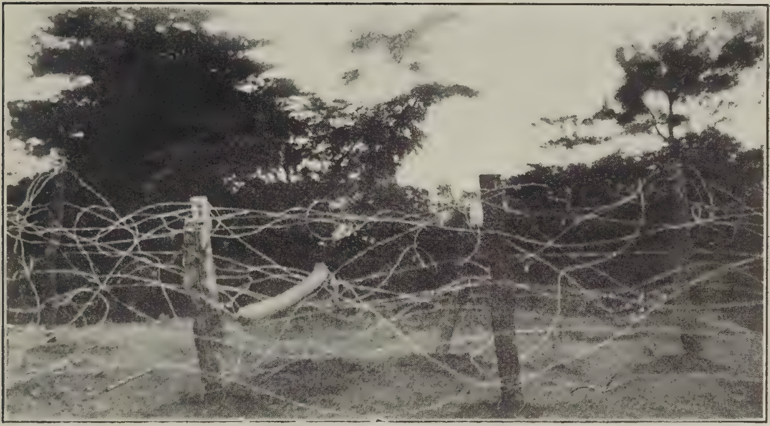


Fig. 2. Ready for first test.

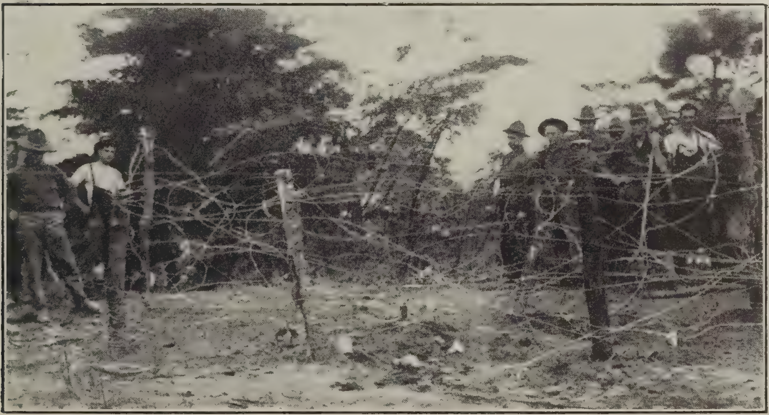


Fig. 3. Results of first test.

b. Method of Placing. This torpedo was placed on the ground touching two posts, as shown in Fig. 4.

c. Result. A gap from 12 to 18 feet wide was opened in the entanglement, in which all the wires were cut except four. The two posts adjacent to the tube were broken short off, one post originally 6 feet away from the tube was uprooted and thrown about 10 feet farther off, and all the remaining posts of the entanglement were loosened and bent. Where the torpedo was resting on the ground, the earth was thrown out, leaving a trench about 8 feet long, 30 inches wide, and of an average depth of 18 inches. The result of this test is shown in Fig. 5.

Third Test.

a. Charge. 12.6 pounds of dry gun cotton, about 1.8 pounds per foot. *One* electric fuse in a priming charge of 3 ounces of dry gun cotton was used in the wooden base plug.

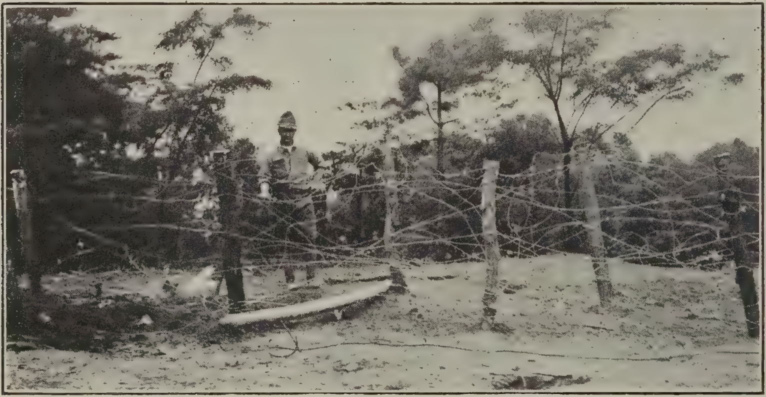


Fig. 4. Ready for second test.

b. Method of Placing. The torpedo was placed in the center of the wires away from the posts as in the English test, and as shown in Fig. 6.

c. Result. A gap 6 feet wide was opened in the entanglement in which all the wires were cut except about *four*. Two of the four nearest posts were bent away from the gap, and the other two were loosened. The remaining posts of the entanglement were apparently unharmed. The result of this test is shown in Fig. 7.

CONCLUSIONS.

The limited extent of the above tests does not warrant any definite conclusions, but it is believed that the following points appear to be fairly well established:

That the "Bangalore Torpedo" has many advantages as a method of assembling and placing the charge when gun cotton is to be used to open a gap through a high wire entanglement, and when used with this explosive appears to give very satisfactory results, quite equal to those claimed for it in the English article.

That when rack-a-rock is substituted for gun cotton as the explosive, great difficulty is encountered in making up the charge so as to insure the detonation of all of the rack-a-rock, this difficulty increasing with the length of the "torpedo" until it would be almost prohibitive with a charge 18 feet long, as used in the English test. Another disadvantage in using rack-a-rock is the increased weight of charge per foot necessary to produce the desired results. This added weight makes the sections of the torpedo difficult to handle, requiring at least two men to place each 6-foot section, and even then if due care is not exercised the sections will break in the middle while being brought up.

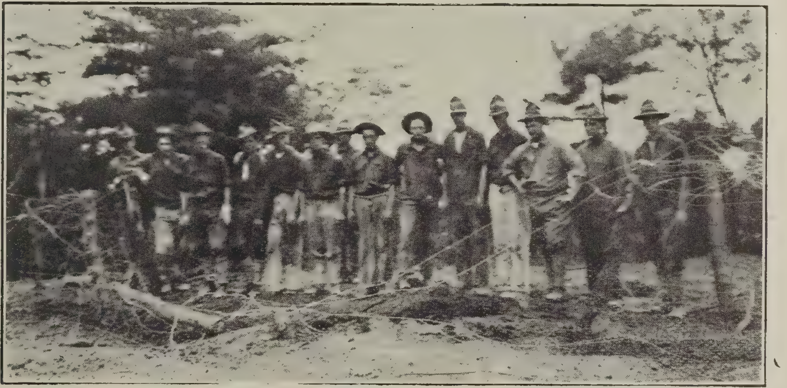


Fig. 5. Result of second test.

It is believed that in placing any charge of explosive for the destruction of a wire entanglement, the charge should be so placed as to exert the maximum force on the posts, and that the wires are broken, not so much by the effect of the explosion on the wires themselves as by the strain put on them when the posts are forced apart. For this reason whether placed on the ground or in the center of the wires, the torpedo should always be placed adjacent to as many posts as possible, at least two.

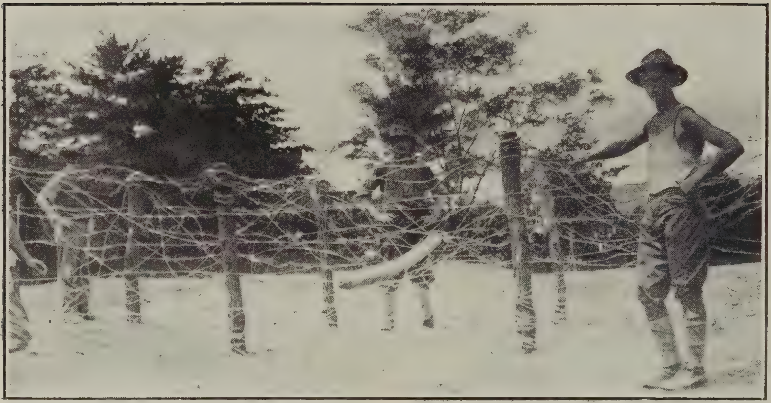


Fig. 6. Ready for third test.

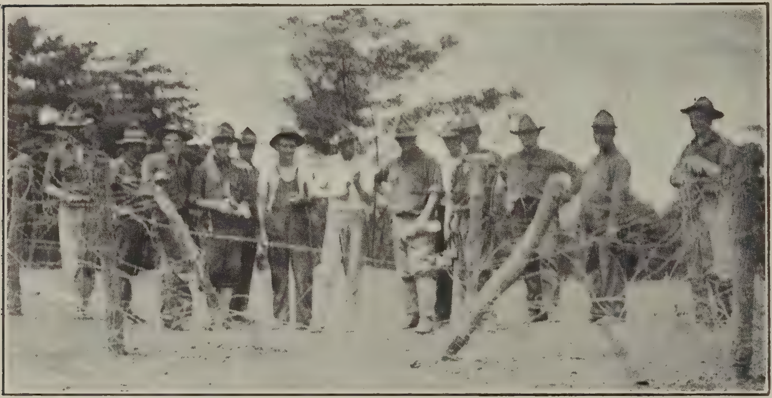


Fig. 7. Result of third test.

Concrete in Sea Water on New England Coast*

BY

Col. FREDERIC V. ABBOT
*Corps of Engineers; Member American Society
Civil Engineers*

In *Engineering Record* of August 19, 1911, page 229, there is a well illustrated article on the result of the test of twenty-four specimens of concrete made by the Aberthaw Construction Company and suspended vertically in salt water at the Boston Navy Yard, early in 1909. Each specimen is 16 feet long and 16 inches square, their tops are above the level of high tide, so that they are submerged at long intervals only. The lower 2 or 3 feet are submerged at the lowest known tides. In this same locality a concrete wharf has been very seriously damaged between high and low water. In the two years covered by the article, which gives full details of composition, wetness, etc., for each specimen, almost all showed more or less deterioration.

On October 18, 1912, I tried to make an inspection of their condition, but found that they had been temporarily removed and were standing on bottom alongside the next pier, at approximately the proper level, but so closely packed together that one-half could not be inspected at all, and of the twelve remaining blocks only the faces bearing the identifying numbers could be seen. I was informed that they will be again suspended below the cap log of Pier No. 9 in about one month. As these blocks were cast in horizontal position and the marked faces, finished with a trowel, were on top, those faces are probably more dense than the backs and sides which could not be seen. No boat was available, so the best that could be done was to note the condition of the visible faces as they appeared from above.

Referring to the blocks by their original numbers, 3, 14 and 16 appeared to be in almost perfect condition. No. 3 was composed of a mixture of Vulcanite, Giant, and Alpha brands of cements in equal proportions, one part of the mixture being used with one part of sand and two parts of stone. Tempered ''very wet,'' cast January 9, 1909; forms off January 11, 1909; immersed March 1, 1909. Lost overboard in about 20 feet of water March 30, 1912, by breaking of suspension hook. Recovered about one month later. No. 14 was composed of a mixture of Lehigh and Helderberg brands in equal parts, one part of the mixture being used with one part of sand and two parts of stone. Tempered ''Wet—quaked with light tamping.'' Cast January 13, 1909; forms removed January 15, 1909; immersed February 23, 1909. No. 16 was composed of iron cement one part, sand one part, stone two parts; tempered ''Wet—when leveled off showed only streaks in water on top.''

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*This paper and the three following ones were submitted at a Conference of Engineer Officers engaged on River and Harbor Work in the Northeast Division, under Col. W. M. Black, October 23-25, 1912.

Block 4 had a rougher surface for its whole length than any of the others, there being little difference in this respect in the part always dry and that exposed daily to the sea water. It was composed of a mixture of Vulcanite, Giant, and Alpha brands in equal parts, using two and one-half parts of sand and four and one-half parts of stone; tempered ''Very dry—no free water, but surface was moist.'' Cast January 9, 1909, forms off January 11, 1909, immersed March 1, 1909. The rough surface may have been due to the dry mix. So far as I could see, this block was but little affected by its three and three-fourths' years exposure and is the only block I saw with a mixture leaner than 1 to 1 to 2 which did not show evident deterioration somewhere. It was dropped overboard in the same way as No. 3 on March 30, 1912, and recovered about a month later.

Block 22 appeared little affected from the top down to a point some 2 or 3 feet below the streaks indicating ordinary high water; from that point down as far as the block was out of water the edge was eaten away to a depth of perhaps 4 inches, measured on the diagonal, and the surface was rough and worn. It was composed of nine parts of the above mixture of Vulcanite, Giant, and Alpha brands mixed with one part of hydrated lime, one part of this mixture being used with three parts of sand, and six parts of stone. Tamped with *salt* water, ''H. lime was thoroughly mixed with dry cement. Quaked with light tamping.'' Cast January 16, 1909; forms off January 18, 1909; immersed February 23, 1909. It is evident that this is not a suitable concrete to be exposed between high and low tide to sea water in this latitude.

Block 23 was similarly affected to a depth of perhaps 5 inches at the corners and less on the flat front face. So far as I could see it looked as though the cross section at the level of about mid-tide was more nearly a circle than the original square. This block was composed of the Vulcanite-Giant-Alpha mixture, using one part of mixture to three sand and six stone. Tempered with *salt* water, using Sylvester process. ''Alum mixed thoroughly with dry cement soap dissolved in water. Quaked with tamping.'' Cast January 16, 1909; forms off, January 18, 1909; immersed February 23, 1909. It is evident that the Sylvester process applied to such a lean mixture did not prevent serious deterioration between high and low tide in sea water in this latitude.

The surfaces of the other six blocks which were accessible for inspection were plainly affected by their exposure, but not to such a degree as to be easy to describe without accurate measurements, which were not possible without a boat.

One block, No. 21, is said to have been lost overboard and not recovered, so only twenty-three specimens are now available for future study. The value of these tests will increase with age, and this office will examine the specimens from time to time.

In the *Engineering Record* for October 21, 1911, there is an illustrated article on patching a concrete sea wall at Lynn, just north of Boston, by the cement-gun process. The wall was built in 1904, about at the high water line for most of its length. I first saw it in 1910, at which time the parts exposed to direct action of the waves were badly pitted. The condition is well illustrated in the illustrations printed in the article. I have been unable to reexamine the wall since the patching, but expect to do so after this winter's exposure to freezing and thawing. If the cement-gun surface plaster adheres that length of time it will be a remarkable and valuable experiment, worthy of copying in similar situations; I am told, however, that in spots the plaster gives a hollow sound already, and this is not a favorable indication of permanency.

Concrete used as foundation for granite block sea walls, built by the United States in Boston Harbor, has without exception shown great deterioration at or a little above mid-tide to high water, having been cut out and replaced in detail from time to time as needed.

The most recent case is a toe built to hold the foot of a sloping pavement of heavy granite blocks (2 or 3 ton stones) which protects the foot of the bluff at Fort Heath. The foreshore is covered with round stones from the size of a man's head up to 3-ton sizes, with intervening spaces where the average would perhaps be the size of a man's fist. These stones are underlaid by clay hardpan, containing boulders, but the action of winter storms has been so severe in the last few years as to degrade the surface of part of this beach several feet. This threatened to undermine the granite pavement and a toe, composed of concrete in blocks some 8 feet long and 2 feet wide on top, was built by excavating to a depth of about 3 feet into the hardpan, putting in tight forms, and filling them with concrete in mass. Alpha cement, which sets quickly, was used.

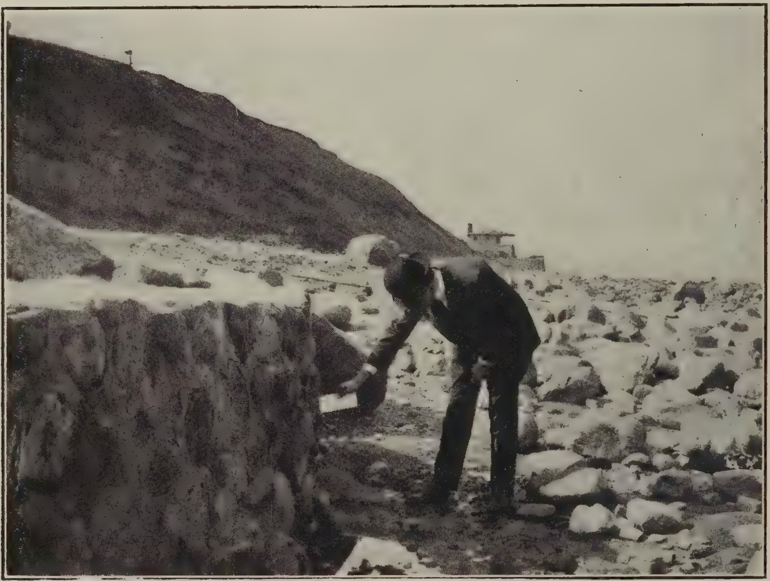

Fig. 1. Showing concrete toe with round stones on foreshore; note stones in face of concrete.

When completed the blocks looked hard and smooth, with excellent faces free from cavities. The work was done in the summer of 1910 and 1911, and no changes showed till after the first winter storms. The illustrations show the worst spots as they appeared on October 18, 1912. Most of the blocks show some pitting, but in the majority no real injury has resulted from the two and one-fourth years' exposure. In this locality it is probable that impact of the stones forming the beach has a good deal to do with the damage. The part of the toe built in 1911 was composed of a concrete body with a face of stones picked up from the beach. This has stood well, as the mortar joints seem to be unaffected so far, and the projecting rounded stone surface is well adapted to stand hammering by similar stones thrown against them by the waves.

In all bridge piers, etc., lately built by civil engineers in the waters of Boston Harbor, concrete has not been exposed to the sea water above low tide level, the middle of the piers being concrete deposited behind a well built granite facing extending several feet above highest tide. This has prevented any visible deterioration. How concrete below this granite facing and continuously exposed to salt water has lasted I have had no means of learning.

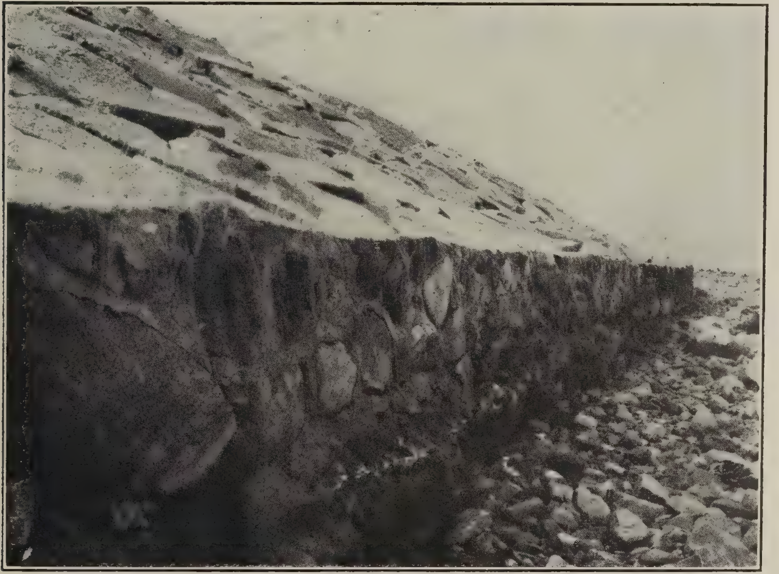

Fig. 2. Very nearly same as Fig. 1, but showing paving blocks better.

A 90-ton concrete monolith in the Sandy Bay breakwater, with its base at level about 4 feet above mean high water, and its upper surface about 4½ feet higher, was built in place in the summer of 1910. The forms were made waterproof with tarred paper, and a similar diaphragm of burlap and tarred paper under the base prevented leakage of mortar and cement. The forms were thus watertight at bottom and sides. The block was composed of Atlas cement, 1 part; of Plum Island sand containing particles from ⅛ inch down, 2½ parts; and of broken granite, run-of-the-crusher screened from dirt and dust, of sizes passing a 1½ ring and retained on a 1¼ ring, 5 parts. The upper surface was trowelled smooth before final set occurred. The forms were left in place as long as it was safe to leave them—that is, until the action of waves began to loosen up braces and planks, which was several weeks after the concrete was poured. In removing the forms care was observed to leave the tarred paper sticking to the concrete surface, which afforded additional protection to the concrete. Wherever the paper came loose the exposed surface was smooth, hard, and free from cavities; the concrete was mixed wet, using salt water, and was well worked into place to ensure freedom from vacant spaces and confined air bubbles. In June, 1911, the block was carefully examined, and the top surface was found perfect. To the vertical exposed surfaces of the block the tarred paper was still adhering generally, but in many small spots it had come off, and in many such places there was evidence of pitting. In the upper parts of the vertical surfaces such pitting was of small depth and area, but along the lower 6 or 8 inches of these faces the pitting was much deeper and more definite in character. The exposed cement appeared to be converted superficially into a soluble, whitish, chalky substance with little cementing power, the projecting parts of em-

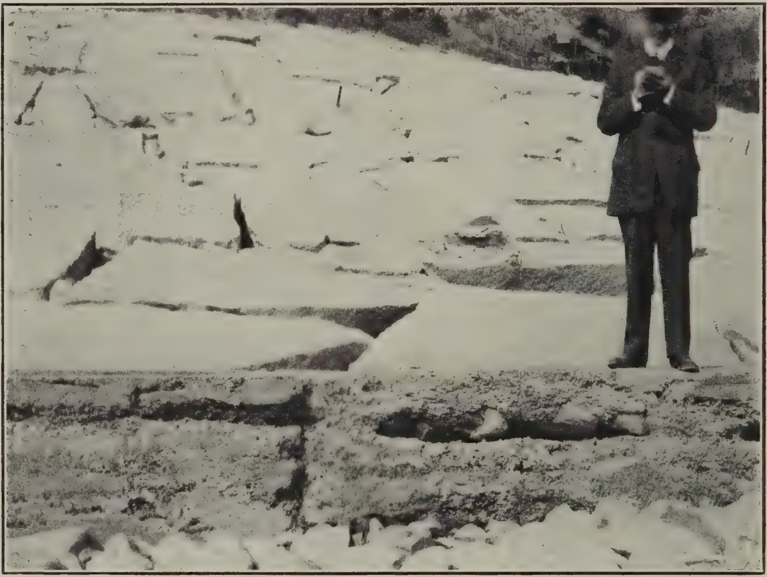

Fig. 3 (see pages 114 and 115). Showing concrete toe where pitted. This concrete did not have stone embedded in it as in Figs. 1 and 2.

bedded stones and particles of sand were generally clean from any adhering cement, but even with a knife blade it was hard to remove stones or even individual grains of sand, as the undeteriorated cement held well. Some stones projecting over half their length broke off before they could be hammered loose from the mass of the concrete. The extreme depth of erosion or decomposition along the lower edge of the block occurred at one corner, where it was about 3 inches, the area being perhaps a square foot. Another examination was made on September 25, 1912. Wherever the tarred paper still remained the surface of the concrete was perfectly sound and smooth, and this covers a large part of the exposed surfaces. This is the greatest height above high water at which I have personally seen concrete in the vicinity show signs of injury by sea water, but the block is where it is exposed at almost every tide in the winter time to the splash, and sometimes to heavy wash of salt water, during freezing weather.

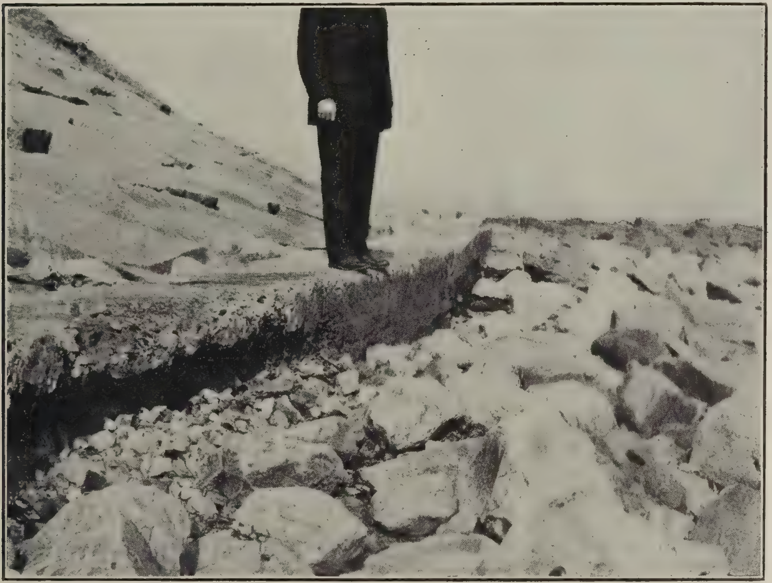

Fig. 4. Same class of concrete as Fig. 3, but at a different spot.

A reinforced concrete sea wall at Fort Andrews, on a rather sheltered beach, and well above high-water mark, though occasionally reached by spray from waves at high tide, shows no surface deterioration, and the same was generally true of the parts of the Lynn sea wall, above described, where the beach had made up sufficiently to protect it from actual contact with solid sea water.

From all I can gather it seems that the surface deterioration is due to combined chemical and frost action, the latter being effective only where freezing and thawing alternate frequently, which is generally confined to the space between high and low water. When waves intervene, as at Sandy Bay, the upper limit of damage is apparently raised, but frozen spray even in great quantities seems to have less effect, for at Sandy Bay a second concrete block, lying on top of the one above described, shows at this date much less damage by sea water. It looks as though damage followed when the contact of the salt water is long enough to thoroughly melt ice in the surface skin of damp concrete, with intervening exposure to the cold sufficient to permit hard freezing of this wet surface. I have nothing to prove this theory beyond the fact of the limiting heights at which deterioration shows.

That the action is partly chemical is probable because no such deterioration has been observed in any of the concrete forming parts of the defenses, even though exposed to freezing and thawing while wet with fresh water. There is, however, an essential difference other than chemical between these cases. Tides occur at regular intervals, so that freezing and thawing alternate, there being two freezing periods and two thawing periods daily. Where battery concrete is exposed to fresh water running from leaky pipes, sub-soil drains, etc., it is generally true that alternations of freeze and thaw are much less frequent.

On October 16, 1912, a Mr. Edward Duryee stated that he has within a month inspected the land lock wall I built of silica cement (1-1), 1 to 3 sand to 6 broken stone (a proportion of 1 cement to 9 aggregate), at St. Paul, Minn., in 1899; and the river wall built in 1900 of regular 1 : 3 : 6 concrete (a proportion of 1 cement to 9 aggregate), by Colonel Lockwood, forming the other side of the lock. Neither wall shows any effect of freezing and thawing, although exposed every winter to temperature from 20° to 40° below 0° F. Eight inch concrete cubes at St. Paul, exposed to daily freezing and thawing after they had set nine days or more, showed no ill effects when mixed wet. (See Annual Report of Chief of Engineers for 1900, page 2780.)

In all cases in and near Boston where concrete surfaces, plaster-finished after the removal of forms have been inspected, the plaster has been loose or absent for considerable areas. This does not hold true of buildings constructed by successive layers of Portland cement plaster laid on metal lath, if each layer has been put on before the preceding layer was fully hardened.

Concrete Where Exposed to Sea Water or Frost

BY

Lieut. Col. W. E. CRAIGHILL
Corps of Engineers

While several seawalls in the Portland, Me., District have been built, there has been no marked case of disintegration of which there is sufficient knowledge to give results of observations as to disintegration, except in the case of the concrete wharf at Fort Williams.

This structure, fully exposed to the sea, is about 50 feet face and 140 feet long, built on ledge and extending into a depth of about 13 feet at mean low tide. The top of the wharf is 14½ feet above mean low tide. The mean rise of tide is 8.9 feet. The wharf was built under contract during the summer of 1908, and exceptionally favorable weather prevailed, which made what was expected to be an exceedingly difficult piece of work one of comparative ease. From the shore out to mean low water the wharf was built of mass concrete. The pier head from thence is of mass concrete within walls built up of concrete blocks weighing from 5 to 10 tons each. The top 4½ feet of the pier head is of mass concrete throughout. The foundation for the blocks was 1-2-4 concrete placed in bags. The blocks, the deck of the pier head, and the facing of the shore block (about 2 feet thick) were of 1-2-½-5 concrete. The concrete hearting was 1-4-8. The heavy concrete blocks were moulded on the shore and were allowed to set for more than thirty days before being used in the work. The concrete was composed of Dexter cement, clean pit sand, and crushed native rock. The cement was thoroughly tested, carefully watched, and met standard requirements. Medusa Compound was used on part of the surface. During storms solid water from 6 to 10 feet deep has been observed to wash over the structure. An angle at the shore end of the seaside producing abnormal wave conditions was filled in the following year by day labor. In 1910 cavities began to appear between high and low water mark, for the most part on the sea side of the wall. This process continued until 1912, when work of repair on that side of the structure was undertaken. Some of the cavities were several feet across and had a maximum depth of approximately 8 inches. During the work of repair several inches in addition of damaged material were removed. There are indications that the use of the Medusa Compound has been beneficial, although some disintegration has occurred where that material was used. There are several causes which may have operated, possibly jointly, to produce the disintegration. Chemical action has been suggested, but I am unable to produce proof of this. Some damage may have been done by loose rocks hurled by the sea against the concrete surface. After storms, ice and rocks were sometimes left upon the deck of the wharf. Another theory is that in constructions so exposed to the sea as this was it is impracticable to prevent more or less wash through the false work, with the result of poverty and porosity of the exposed surface. As the tide recedes nearly 9 feet, there is opportunity for hard freezing and consequent disintegration. Vibrations of the false work during the time in which the concrete is taking its initial set, too much economy in the use of cement in the mixture, and the impracticability of absolute protection until the concrete is set, are all probable factors. In the repair during the present year it has been necessary to remove much weakened material and about $500 has been spent in repair of the easterly face alone. In doing this work material comparatively new to this office, known as ''Metalcrete,'' was used. The idea advanced in connection with this material is that it is a pulverized material which through subsequent oxidation fills the pores in the concrete. It appears well now, but time alone will determine its real value. This wharf cost, with its approach, about $49,000. The present work of repair is the first of importance.

ROCKLAND BREAKWATER.

This work, which is the most striking one in this district, is about 4,350 feet long. The cost approximated $615,000. The total quantity of stone used was 788,490 short tons. It was commenced in 1881 and, though practically finished some years since, has been held open for observation and occasional repair, though nothing has been done for several years. The depth ranges from about 30 feet to about 50 feet. The slopes as a rule are 1 on 1. The material, which is granite, consists of stone brought from the adjacent quarries and varied in size from 1,000 pounds to 6 or 7 tons, the heavier stone being on the eastward or sea slope, which is exposed to a rake of about 16 miles across Penobscot Bay. Prices have ranged from 56 cents to 93½ cents per ton, depending on conditions at the time. During the earlier part of the work many of the granite quarries had large quantities of waste stone on hand which could be secured cheaply and if they were not too far from the breakwater the freighting cost could be reduced to a minimum. As a rule, stone and granite of this character can be purchased from the Penobscot Bay quarries and placed within reach of the vessel's tackle for about 25 cents per ton. The freighting cost depends largely on distance and size of craft, but with a 400-ton lighter stone can be freighted at a profit to a distance not to exceed 20 miles for not more than 50 cents per ton with efficient equipment and management. Short tons are referred to.

The breakwater is 16 feet wide on top at the level of mean high tide and above high tide has a capping of heavy rough dimension stone about 4 feet in thickness. After this capping was laid there were several instances of disturbance by wave action. Stones on the outside were thrown up on edge and a number of instances occurred of cap stones on the inner side being thrown out of place, due probably to the development of hydraulic pressure through the joints against the face of the stones. To correct this the joints were carefully filled with small spawls and pebbles, since which practically no disturbance has occurred. Some riprap was also placed along the seaside to afford greater protection. The riprap itself has not experienced much disturbance, except in the case of a few stones with large surfaces. Stones which are reasonably large, regular in shape, but whose dimensions are not largely disproportioned, when fairly bedded suffer little disturbance. The material for building this breakwater was, in its early days, brought to the work in small sloops and schooners carrying from 90 to 125 tons. Later, larger vessels were used with greater satisfaction and more profit to the owners. It is not usual to be able to secure great depth of water at the quarries, so that vessels of light draft carrying from 200 to 500 tons have proved the most useful in this district.

MATINICUS BREAKWATER.

Matinicus Breakwater is on the eastern side of Matinicus Island, which lies in the open ocean at the mouth of Penobscot Bay. It is a very rough place and exposed to the full sweep of the Atlantic. The breakwater is about 450 feet long, 10 feet wide on the top, 15 feet above mean low tide, with side slopes of 1 on 1½. The bottom is ledge and for the greater distance dry at mean low tide. Owing to the character of the bottom and the great exposure, the breakwater was urgently needed and the construction and maintenance expected to be correspondingly difficult. About 9,000 tons of stone were placed during the summer of 1911, at a cost of $1.30 per ton laid in the work. Most of the stones were large, many of them weighing from 10 to 12 tons each and some 15 tons. These were carefully laid as conditions would permit, with a view to firmly bedding and binding the stones together, but the surface was left very irregular and rough, with a view to absorbing and breaking up wave energy. About one year after the completion of the breakwater it was examined and the result is quite gratifying. Though exposed to the severe storms of last winter it is reported that no change has occurred and that the breakwater is practically as constructed and that it has been exceedingly efficient in protecting the small harbor. The greater cost of this work was due not so much to the larger size of stone used as to the difficult and dangerous place of construction.

BAR HARBOR BREAKWATER.

This work is yet unfinished; however, a contract has been made for its completion, at a price of 77½ cents per short ton. The breakwater for the most part is in deep water, about 50 feet. Small stone is allowed to be used in the core, but the face or cover is to be of large sizes, no piece to be of less than 3 tons. The top of the breakwater is to be at the level of mean high tide and the slopes 1 on 1. The work has been in progress since about 1889, and examinations made from time to time indicate that the slope of 1 on 1 practically maintains. There is no particular difficulty at this place in maintaining the work so far and little is expected. The material is of granite, irregular in shape; in other words, what is locally known as grout or refuse from the quarry. Care is taken in all cases to see that the stone is sound and not liable to disintegration.

The above fairly represent the breakwater construction in this district. They are those which most strongly show the characteristics and lead this office to the opinion that an irregular surface of heavy stones well bedded afford the best means of resisting wave action, that flat stones or stones with large plane surfaces should be avoided, and that for capping and for the top of the work joints should be filled and chinked, even at some expense, to prevent the development of pressures which will either up-end or dislodge the stones of greater dimensions used to finish the work. Ice action has given but little trouble here, though some cases have been observed which were thought to be due to that cause. The water being salt, the ice is rarely firm enough to give much trouble, though it frequently forms in large quantities. It may be interesting in this connection to note that fishermen who drive stakes for fish weirs in this State state that the influence of ice on the stakes is to lift them.

The above cases are rough rubble masses or dumps, which is the characteristic and cheapest way of building breakwaters in this district and has been followed with rare exceptions.

Concrete Laid in Freezing Weather, New York State Barge Canal

BY

Mr. D. A. WATT

Assistant Engineer; Member American Society Civil Engineers

PROPORTIONS.

The proportions used for practically all concrete on the New York State Barge Canal were 1 part of Portland cement, 2½ parts of sand, and 5 parts of gravel or broken stone, all measured in loose bulk. Much of the concrete had to be laid in freezing weather, in a few cases with the temperature at zero or below. This was due to the fact that some of the locks, stream culverts, etc., were in the old canal, which had to be kept in commission from the middle of May to the middle of November, leaving only the winter and early spring months in which work could be done at such locations. Thus, the lock at Whitehall, at the south end of Lake Champlain, had to be built entirely in the winter time, and much of the concrete was laid at temperature not far from zero. In only one part—laid when the thermometer was at 20° below zero—was any of the work injured by frost.

HEATING THE MATERIALS.

The specifications required the materials to be heated in freezing weather. With not more than a degree or two of frost it was usually found sufficient to heat only the water, unless the concrete was in a small mass. With a large mass and proper surface protection, the setting of the concrete generated heat enough to prevent damage from the cold. Where the frost was more intense, however, or where the mass was small, the other materials were required to be heated also. This was done in many cases by placing steam coils in the bins, but the heating effect was slow, and in very cold weather was unsatisfactory, requiring a constant shoveling of the material in the bins in order to distribute the heat properly, and causing delay at the mixer until a sufficient amount had been heated. Much better and quicker results were obtained by piercing the coils with small holes, thus forcing the steam through the adjacent material.

The best results, however, were obtained by turning a jet of steam into the box of the mixer (usually the exhaust of the engine was employed), which resulted in all the particles being heated thoroughly and uniformly during the minute or two they were being revolved. With this method the sand and stone could be taken directly from storage—often coated with a film of ice—and were turned out well heated and at a rate equal to that of warm weather.

PROTECTION WHEN IN PLACE.

Except for the top surface of the layer last placed, no special protection was found necessary. The thickness of the outside lagging—1¾ to 2 inches—appeared to be sufficient to protect the sides, even in the severest weather, as the heat generated by the concrete when setting was enough to crystallize the mixture to a point where the cold could not afterwards affect it. Most of the lagging for the lock culverts were made of 1-inch stuff and proved in these locations equally efficacious, as the heat from the surrounding concrete prevented the cold from penetrating. This thickness, however, was insufficient for exposed surfaces unless the frost was very slight. Thus, the nose of the pier of the bridge dam at Tribes Hill (Mohawk River) was rounded in design, and was accordingly made of 1-inch plank; the remainder of the forming was of 2-inch plank. During the building of the pier the weather changed suddenly and became bitterly cold in a few hours, and the temperature fell to near zero, accompanied by a strong west wind which blew directly against the nose. The materials for the concrete were properly heated and the pier was completed as fast as possible, but when the lagging was removed in the following spring it was found that all the part protected by the 1-inch lagging had been frozen to a depth of 6 or 8 inches, while the remainder of the pier was unhurt.

Top surface protection was secured in moderately cold weather by layers of plank, laid closely enough to keep in most of the heat rising from the mass below. In colder weather a thick layer of sand or earth was used, or if the protection was required for a short time only, as for the interval from one day to the next, steam pipes were laid on the concrete and covered with plank or canvas. These pipes were occasionally used also instead of sand or earth.

AMOUNT OF SETTING REQUIRED TO PREVENT INJURY.

After the concrete had obtained a good initial set, which would require perhaps twenty-four hours in cold weather, the temperature did not appear able to affect it. By that time the crystallization appeared to have advanced far enough on the surfaces to prevent the frost from injuring them subsequently. The lagging, with all winter-laid concrete, was left on for several days and often longer, and on its removal the face of the concrete was soft enough to scratch with the finger nail. This softness was found to be about the same, whether the lagging had been left in place for a few days or for many weeks, and lasted until the warm weather of the succeeding spring, when the wall would begin to dry out gradually and the surface to become hard. The upper guide wall of the Mindenville Lock, for example, completed some months previously, was examined by the writer in April, and the surface could be easily dug out with the heel. It was surmised that frost might have spoiled it, but on a later examination, after some weeks of warm weather, the wall was found to have become perfectly hard. Such conditions were found with all walls laid in winter.

EFFECT OF LAITANCE.

Much of the concrete on the Barge Canal shows defective spots, especially on the coping. In my opinion, this has been due almost entirely to excess of laitance or inert matter in the mixture. The early specifications for sand, etc., made no allowance for the presence of loam, but it was found necessary in the later ones to permit a small percentage in order to avoid unreasonable washing of the materials.

Where too much water was used in the mixing, as was often the case, this loam and such impurities or ''padding'' as existed in the cement floated to the surface and gradually collected from succeeding batches in a layer of yellowish, soapy, mud-like material, with the cohesion, when dried, of chalk. It appeared to be worse with certain brands of cement, but the greater part seemed due to impurities in the other materials. Where insufficient care was taken and where the laitance was not properly removed, it ran against the lagging when the concrete was forked back to give a mortar face, and in many cases a thin film was left also on the coping by the finishers. Such films always became loose during the winter, leaving a ragged top and often exposing the stone just beneath. A good many of the loose patches on the coping of the earlier work, however, were due to the puttng on of a separate finishing coat of mortar. While this method appears successful with sidewalks, equally good results appear difficult to obtain on other contract work, and all the later copings were accordingly finished with the usual mixture of concrete, the stones being driven down and the surface smoothed at once with a wooden float.

Laitance gave no trouble except where the water came to the surface of the concrete; where the mixture was only moderately wet it appeared to remain unseparated from the mass, and did not flush to the top. I do not remember having met with it in the "dry" concrete which was so often used until a few years ago. One objection to carrying concrete for some distance in dump cars or boxes was that the water tended to work to the surface and brought up laitance with it.

The presence of a large amount of stone dust was another cause of laitance. Its effect, where the concrete was not wet enough to separate it from the mass, was to produce a very dense or watertight wall, but one that was scarred easily and that did not possess proper hardness.

GENERAL.

Too much care can hardly be exercised in the effort to avoid the effects of this laitance. A small amount of fine matter in the mixture appears to be beneficial in making the concrete watertight, but if it collects on the surface of the work it should be shoveled outside of the forms at once and steps be taken to prevent its further appearance. Where the concrete on the Barge Canal has been cut out or drilled into for machinery, etc., it has shown a dense hard mixture, and the soft layers and surface spalling occasionally met with are evidently due to local imperfections.

On the few locks recently put into service some scarring from boats is visible also, as well as chafing from lines. The latter effect is principally due to the dragging along of sandy tow lines as the boats pass in or out, and should cease when animal traction is abandoned, as will be done as soon as the canal is finished. On the existing canal this chafing has cut deep grooves in hard limestone coping blocks, and even in iron snubbing posts, showing the desirability of adequate protection.

Discussion on Concrete*

BY

Col. W. M. BLACK, Col. F. V. ABBOT, and Col. JOHN MILLIS
Corps of Engineers; Members American Society Civil Engineers

There seems to be a marked difference of action in concrete of the same composition when exposed to severe frost in fresh water and when exposed to tidal sea water in the latitude of Boston and on the northeast coast. Concrete placed in the breakwater in Lake Champlain at Burlington in 1904 shows no sign of deterioration, although exposed to heavy frost and to ice action. This concrete is completely incased in ice in the winter, due to the wave action. Its base is about low lake level. On the break-up, the ice is piled over the top of the breakwater. Various brands of cement were used in the Burlington breakwater, and the concrete is continuously submerged for the lower foot or two throughout the winter, the remainder of it being in the air.

In mixing the concrete the greatest care should be taken to see that the proportions of the ingredients in the mixture shall be exactly as specified. This requires care and watchfulness in every step of mixing and placing the concrete. For example, in the Portland district, batteries were under construction for a number of years. The stone was quarried about 200 miles away, brought in barges to near the site of the work and handled from the barges to the stone pile, and then handled from the pile to the mixer. The stone as purchased was the run of the crusher, between ¼ inch and 2 inches in size. As the result of the long carriage and many rehandlings, the smaller and the larger sizes of the stone became separated in the pile, so that it was impossible to obtain from the pile, direct, stone properly graduated in size. Some batches would be composed of fine material and some of the coarse stone. This difficulty was later overcome by having the stone delivered in two parts—one to contain the stone from ¼ inch to ¾ inch in size and the other to contain stone from ¾ inch to 2 inches. The proper proportions of the stone required in the concrete were then obtained by taking the necessary amounts from the two piles. In another case the concrete was mixed quite wet, about ½ mile from the site of the battery and was conveyed from the mixer to the battery over a rough construction railroad. It was found, on delivery at the battery, that the coarse and the fine materials had separated in the hopper and the concrete had to be remixed before being deposited. Later it became necessary to construct some large concrete water tanks for the service of Camp Columbia, near Havana, Cuba, and it was necessary that the concrete in the tank should be uniformly dense. Inasmuch as there was a variation to be expected in the graduation of the stone and also in the quality of the sand supplied under the contract, the specifications called for concrete in which the amount of cement used in the mortar should be 15 per cent in excess of the volume of the voids in the sand, and the amount of mortar to be used with the coarser aggregate should be 20 per cent greater than the volume of voids found in this aggregate. After each batch of sand and stone had been delivered, the volume of voids in the sand and in the stone was determined by the inspector and the proportions of the cement, sand, and concrete were determined by volume and furnished the contractor in figures which would give the desired results and which were convenient for measuring these quantities by volume. No difficulty was found in carrying out this policy and the results were all that could be desired.

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*This discussion was in connection with the three previous papers.

COLONEL ABBOT

I have heard the opinion expressed that concrete of a quaking consistency is the best to use when it is exposed to alternate freezing and thawing. Experiments seem to show that the most dense concrete, that in which a cubic yard weighs the most, results from a comparatively dry mix, corresponding to this quaking consistency. If forms are not water-tight and concrete is very wet, the water and cement run out of the cracks, leaving an uncemented mass. After setting, even when water-tight forms are used, the excess water evaporates, leaving a very porous concrete. With the ''quaking'' consistency, continuous ramming gives the mass a consistency something like raw liver, and if reinforcing rods do not interfere, a solid, dense, non-porous concrete results. With concrete of this quaking consistency, the laborers sink into it about 4 or 6 inches, but for battery concrete I use a little wetter mixture as being more certain to have a smooth face, the men sinking into it 8 or 10 inches. It is difficult to make laborers use the rammer vigorously enough to insure a good face with quaking concrete.

The action of the adopted sand with the actual brand of Portland cement used deserves careful consideration. At St. Paul, Minn., the underlying sand rock is composed of pure silica with grains weakly cemented together. When blasted it falls into a very clean fine sand. As large quantities of this rock had to be excavated from a lock chamber, it was thought that it might be possible to use this sand for the concrete lock walls. Actual tests showed, however, that briquettes made with this sand failed entirely to set, even with mixtures as rich as 1 cement to 1 sand. The engineering periodicals have recently discussed why some sands do not form a proper mortar with Portland cement, the suggestion being made that the grains of sand which appear satisfactory to the eye may have a coating of some vegetable colloid. I think there may be something in it. The St. Paul sand, although it looked good, could not be used at all, and other sand, of no better appearance, had to be hauled long distances to the lock site at considerable cost.

The Connecticut Avenue Bridge, over Rock Creek, in the City of Washington, is built of concrete in mass, and to give it an attractive surface it was bush hammered. When first finished it simulated the appearance of granite perfectly. After the first winter much of the surface layer scaled off, leaving the embedded stones exposed, destroying the similarity to a natural stone.

COLONEL MILLIS

Gave general remarks relative to the proportions of the several ingredients as affected by the peculiarities of the material to be used. With broken stone, the crystalline structure of the original rock as determining the form of the individual pieces when broken, as well as the chemical composition of the rock, nature of the surfaces, and variations in the sizes of the fragments are all important. Even with gravel and sand, the form of individual particles and their variations in size have an effect in determining the best proportions for the ingredients and amount of water to be used. It is advisable to experiment quite extensively and with samples or ''batches'' of considerable size, to determine the best proportions. With small samples or cubes that are sometimes used for this purpose, the surface effects of the sides of the receptacle may detract from the reliability of the results when applied to concrete in large masses.

There is not necessarily any direct relation between best proportions for concrete ingredients and integral numbers, like ''1-3 and 5,'' etc. There is no practical inconvenience as a rule in applying any fractional proportions that may be determined, since it is almost always a mechanical process, based on proper proportion of the dimensions of fixed receptacles for the sand, cement, and gravel or broken stone.

The Battle-Sight*

BY

Maj. AMOS A. FRIES
Corps of Engineers; Member American Society Civil Engineers

"Your piece is too high; raise it."

This remark was supposed to have been made by a tactical officer at West Point when the writer was a cadet, and earned for that officer the title of "Wooden," and yet there seems to be no other phrase that fittingly expresses the adoption of the present battle-sight for the new Springfield rifle. Perhaps, however, we should slightly paraphrase it and say "Your gun shoots too high; raise the sight."

Every student of fire tactics, that the writer is familiar with, has taken occasion to emphasize the fact that the universal tendency of soldiers in battle is to shoot too high. Everywhere, even in our common school histories, we read of our heroes cautioning men to hold their fire and to shoot low.

In face of that fact, we have to-day a battle-sight that causes the bullet to strike the point aimed at at a distance of 530 yards, only. At every other point between the muzzle of the gun and 530 yards the gun shoots too high in varying amounts as follows:

At 50 yards, 8 inches; at 100 yards, 15½ inches; at 200 yards, 25½ inches; at 300 yards, 28½ inches; at 400 yards, 22 inches; at 450 yards, about 16 inches; and at 500 yards, 7 inches. These values were obtained from the Ordnance Manual by interpolation and are probably correct to within ½ inch.

It is supposed that the theory of the battle-sight is based on the fact that a man kneeling is some 40 inches high and that if a shot

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*The above article on the battle-sight was written and in the hands of the printer sometime prior to the receipt of the *Infantry Journal* for November-December, 1913, in which the same subject is discussed. However, in view of the importance of the subject, the above article is presented exactly as it was originally written.

be aimed at about his thigh he will be hit somewhere between his thigh and the crown of his head, no matter what the range is, provided it be not greater than 530 yards. It is presumed, of course, that the aim is correct. To-day, however, no man but a fool, or a savage with bow and arrow, kneels or stands up in battle, except it be impossible for him to see the enemy when lying down, due to some intervening obstacle. Now, an obstacle that prevents the enemy from seeing you except when he is kneeling or standing will prevent your seeing anything of him except his head or possibly a little of his shoulders, and will generally stop your bullet from hitting him anywhere except in the head or shoulders. Under such conditions, if you use the battle-sight you can not hope to hit the enemy at ranges from 100 to 450 yards unless you aim at an unknown spot in the earth, shrubbery, or grass in front of him, and even then to hit him you must not only estimate your range accurately, but you must pick out very closely the exact point to aim at. What confidence would even a Davy Crockett, or a Buffalo Bill, have in such a sight? Not only do men in battle now lie down as close to Mother Earth as the human form will let them, but if possible they dig holes to make themselves still more inconspicuous.

Furthermore, in modern battles, the artillery is counted upon to keep down the fire of the defense until the attackers are within 200 yards—some claim to within 100 yards or even less. This being true, the extremely critical range for the defenders is between zero (0) and 200 yards. Since, as before stated, the rifle shoots from 8 to 25½ inches too high between 50 and 200 yards, the defenders must be marvelous shots to hit an enemy lying down within those ranges.

True, a man may now raise the leaf and set his sight so his gun will shoot where he holds it, but the leaf is so high and so prominent as to be easily damaged, besides not being suitable for surprise fire or quick work generally. If this were not so, there would be no excuse whatever for any other kind of sight.

Why not give us a rifle with a battle-sight whose range is 100 yards? Then, if it is desired to avoid raising the leaf for ranges beyond 100 yards, the sight could be arranged as on the old Winchester rifle, with a spring-controlled slide to raise the battle-sight up to a range of 600 yards before the leaf need be used. Then your rifleman would know that when he aimed properly he would hit what he aimed at, and at practically any range.

It may be argued that if he has his sight set for, let us say, 600 yards, he may forget it in the heat of battle. Suppose he does. He will be no worse off then than he is now, while if he only happens to have it set at 300 yards he is better off and, still further, the man who keeps his head in battle can set his sight so that it will shoot where he aims. The whole theory of target practice is hinged on trying to get a man to sight at what he wants to hit, and yet we give him a gun with a battle-sight which hits *anything* but what he aims at.

Lieutenant-Colonel David Du Bose Gaillard

(*See Frontispiece*)

David Du Bose Gaillard was born in Winnesboro, Sumter County, South Carolina, September 4, 1859, just when the cloud of the great Civil War began to settle over the Southern States. The Gaillard family in South Carolina dates back to the early Huguenots and, as was then more or less the custom in the South, young Gaillard received all his education up to his fifteenth year in private schools.

In 1880 he was appointed a cadet at West Point, graduating four years later fifth in his class. Upon graduation he was assigned to the Corps of Engineers and reported for duty with the Battalion of Engineers then stationed at Willets Point (now Fort Totten, N. Y.). There he took the prescribed course in Civil and Military Engineering which, at that time, covered a period of three years. He was then ordered to Florida as an assistant to the Engineer officer in charge of river and harbor work in that State. In 1891, when he had been about four years on duty in Florida, he was promoted to First Lieutenant and made a member of the Boundary Commission, charged with surveying the boundary between the United States and Mexico. Although this assignment lasted for five years, active work ended in 1895, when he was assigned to duty at Fort Monroe, Va., in charge of the seacoast defenses of that locality. In October of that year he was promoted to Captain, Corps of Engineers, and transferred to Washington, D. C., first as assistant and later as officer in charge of the Washington Aqueduct for supplying water to the District of Columbia, on which duty he remained until May, 1898, with the exception of about four months in the fall of 1896 when he was engaged in making a survey of Portland Channel, Alaska. At the beginning of the Spanish-American War in May, 1898, he was assigned to duty as Engineer Officer on the staff of Maj. Gen. J. F. Wade, United States Volunteers, but a month later was promoted to Colonel in command of the Third Volunteer Engineers. He commanded that regiment in various camps in the United States until February, 1899, and in Cuba from February 8, 1899, to April 13, 1899, and again in the United States from April 13 until honorably mustered out May 17, 1899. Upon his relief from duty with the Third Volunteer Engineers, he was ordered to Washington, D. C., as assistant to the Engineer Commissioner of the District of Columbia. From there he went to Lake Superior in 1901, and for two years was in charge of river and harbor works on the shores of that lake. It was at this time that he completed his book on "Wave Action," to-day one of the standard authorities on the action of waves and the pressures produced by them. In 1903 he was made Chief of Staff of the Department of the Columbia at Vancouver Barracks, Washington. He remained on this duty less than one year, when he was ordered to St. Louis on duty with the General Staff and as Engineer Officer of the Northern Division. In April, 1904, he was promoted to Major, Corps of Engineers, and in November of that year was returned to Washington, D. C., for duty with the General Staff, where he remained until November, 1906, when he was ordered to Havana, Cuba, as chief of the Military Information Division, Army of Cuban Pacification. On March 16, 1907, or less than a month after his return from Cuba, he was appointed a member of the Isthmian Canal Commission. During his first year as a member of the Commission he was in charge of the Department of Excavation and Dredging, preliminary to the beginning of extensive work under the permanent organization. This organization took effect July 1, 1908, when he was made Division Engineer of the Central Division, which extended from Gatun Locks to Pedro Miguel, thus including all excavation for the Culebra Cut and the approaches thereto. He remained on the Isthmus until August, 1913, less than four months previous to his death, having in the meantime attained the grade of Lieutenant-Colonel in April, 1909.

The foregoing brief record of Colonel Gaillard's professional services speaks eloquently for his talents and ability. In his more than twenty-nine years of continuous active service he has filled positions of great responsibility and trust, covering a wide and varied field of duty, both as a military and as a civil engineer. His successful prosecution of the monumental work on the Culebra Cut of the Panama Canal, one of the greatest and most trying of engineering problems, constitutes a crowning achievement in a life characterized by conscientiousness, loyalty, and modesty.

His friends and intimates will remember Colonel Gaillard, not only for professional attainments of the highest order, but also for his character as a man, husband, and father. Possessed of a cheerful temperament and of a never-failing good humor, he was always a welcome addition to any gathering. A life so well spent must indeed serve as an inspiration to coming generations.

Book Review

Principles of Industrial Organization. By Dexter S. Kimball; 272 pages; 20 illustrations. McGraw-Hill Book Co. *Price, $2.50.*

Professor Kimball states in his preface that the purpose of this book is not to exploit any particular form of industrial management or any specific remedy for industrial evils, but rather an endeavor to set forth the salient facts regarding the principal movement, and to explain the origin and growth of the important features of industrial organization. The historical development is traced briefly from the time when production depended on primitive tools and manual labor to our present highly developed factory system, which depends on congregated effort and the use of machinery.

The effects of the industrial revolution following the invention of the steam engine and the spinning and weaving machines are outlined. The salient features are given of factory welfare work, factory legislation, and labor unionism and industrial education, all of which have grown up to modify factory methods and conditions resulting from the industrial revolution. The modern tendencies toward aggregation, specialization, and standardization are discussed with the advantages and disadvantages of each.

The author next goes into the interesting modern field of efficiency engineering or scientific management. The principles underlying economic production are laid down. Systems developed in compliance with these principles are discussed under the following heads; Planning departments; principles of cost keeping; depreciation of wasting assets; compensation of labor; purchasing, sorting, and inspection of material; location, arrangement, and construction of industrial plants, résumé—theories of management.

The book offers the groundwork of industrial organization and is so full of the keen, practical ideas of the author that it should be not only of interest but of value to every engineer charged with the purchase and care of material or the handling of men.—E. J. A.

Table of Engineer Districts

Districts.	*Expenditures, Fiscal year 1913.*	*Order, by money spent.*	*Number of employees June 30, 1913*	*Order, by number of employees*
Baltimore	$139,130.65	54	28	57
Boston	478,708.15	34	210	36
Buffalo	922,150.04	21	116	45
Charleston	419,064.50	37	230	34
Chattanooga	635,923.33	31	725	6
Chicago	191,439.82	51	102	46
Cincinnati, 1st	569,777.82	32	220	35
Cincinnati, 2d	389,290.17	39	247	30
Cleveland	944,737.21	20	101	47
Dallas	984,310.45	19	367	19
Detroit	2,488,376.84	1	314	24
Detroit — Lake Survey	130,500.15	56	150	42
Duluth	386,163.83	40	169	39
Galveston	1,839,342.84	4	459	14
Grand Rapids	156,982.55	52	59	51
Honolulu	371,319.81	42	241	31
Jacksonville	1,023,922.01	18	188	37
Kansas City	1,048,294.44	17	1063	4
Little Rock	242,982.16	48	125	44
Los Angeles	366,359.73	44	50	52
Louisville	747,531.97	27	344	21
Manila	783,031.74	24	1186	2
Milwaukee	377,997.49	41	175	38
Mobile	1,517,848.16	6	739	5
Montgomery	642,090.95	30	612	8
Nashville	217,517.18	50	286	25
New London	368,050.25	43	78	49
New Orleans	1,179,096.09	12	457	15
Newport	773,721.98	25	159	40
New York City, 1st	1,099,331.33	14	565	10
New York City, 2d	786,538.13	23	153	41
New York City, 3d	141,970.19	53	28	58
Norfolk	1,309,037.46	8	147	43
Philadelphia	1,252,054.55	10	279	26
Pittsburg	1,095,140.76	15	564	11
Portland, Me.	240,856.32	49	37	53
Portland, Ore., 1st	1,072,784.64	16	398	16
Portland, Ore., 2d	1,411,839.97	7	505	13
Porto Rico	9,622.42	64	4	59
Rock Island	1,606,424.30	5	1271	1
Savannah	807,786.24	22	271	27
San Francisco, 1st	765,136.93	26	85	48
San Francisco, 2d	55,806.12	61	33	55
San Francisco, 3d	337,455.25	45	73	50
Seattle	1,177,149.56	13	523	12
St. Louis	746,870.52	28	1176	3
St. Paul	309,919.19	46	387	17
*Vicksburg	706,695.86	29	336 (600)**	23 (10)
Washington — R. & H.	497,911.90	33	243	33
Washington — P. B. & G.	410,525.73	38	372	18
Wheeling	1,287,098.27	9	609	9
Wilmington, Del.	277,239.56	47	37	54
Wilmington, N. C.	422,305.39	36	244	32
Yellowstone Park	116,608.17	57	342	27
Mississippi River Commission.				
*Office of the Secretary	476,756.94	35	361 (500)**	20 (14)
*1st and 2d Districts (Memphis)	2,105,151.20	3	708 (800)**	7 (5)
3d District—Vicksburg	2,283,199.79	2	271 (800)**	28 (5)
4th District—New Orleans	1,242,633.47	11	270 (800)**	29 (5)
Washington Barracks	138,487.36	55	29	56
Washington, O. C. E.	103,923.08	58	25	
	$44,629,922.91		19546	

*Working season not commenced. **Average in working season.

Editorial Notes

Prizes for Articles for 1914

For articles accepted and published in Nos. 25 to 30, inclusive, comprising Volume VI to be published in 1914, the PROFESSIONAL MEMOIRS will award four prizes, as follows: Fifty dollars for the best article; twenty-five dollars for the second best; fifteen dollars for the third; and ten dollars for the fourth.

This offer is open to all subscribers to the PROFESSIONAL MEMOIRS, except officers of the Corps of Engineers with more than ten years' commissioned service in the Corps. The School Board of the Engineer School, which publishes the PROFESSIONAL MEMOIRS, will decide on the best articles and rate them as first, second, etc.

Articles of any length whatever will be considered for all four prizes, though naturally a good article of considerable length will be rated higher than one of relative merit though shorter. Professional excellence, clarity, and conciseness are considered of prime importance, though literary excellence will be considered in making the award. In addition to the above prizes and in accordance with the precedent of the past two years, one year's free subscription will be given to each author of an article of twelve pages or more, if that article be not awarded one of the four prizes above mentioned.

Number 2, Volume I

This number has been out of print for nearly two years, but has now been reprinted and copies are available for sale to any who may wish them, the price being one dollar per copy.

Award of Prizes

The School Board of the Engineer School has awarded the four prizes offered for the four best articles published in the PROFESSIONAL MEMOIRS during the year 1913 and has forwarded checks for the amounts of the prizes as follows:

First Prize, $50. To Mr. Frederick C. Schubert, Member American Society of Civil Engineers, Assistant Engineer United States Engineer Department, First Portland, Ore., District, for his article published in No. 22, entitled "The Dalles-Celilo Canal."

Second Prize, $25. To Capt. Thomas H. Dillon, Corps of Engineers, U. S. Army, for his article published in No. 24, entitled "Building a Ponton Bridge in Swift Water."

Third Prize, $15. To Mr. T. P. Roberts, Member American Society of Civil Engineers, Principal Assistant Engineer, Pittsburg, Pa., for his article published in No. 23, entitled "Pros and Cons on the Forest and Flood Question."

Fourth Prize, $10. Mr. M. L. Tower, Assistant Engineer, First San Francisco District, Member American Society of Civil Engineers, for his article published in No. 23, entitled "Rebuilding Jetties at Humboldt Bay, California."

PROFESSIONAL MEMOIRS

Corps of Engineers, United States Army, and Engineer Department at Large

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Maj. FREDERICK W. ALTSTAETTER, *Editor*. Lieut. EARL J. ATKISSON, *Business Manager*.

VOL. VI. MARCH-APRIL, 1914. NO. 26.

Contents

(*Illustrations in each article are shown by italics.*)

Page.

1. DULUTH-SUPERIOR HARBOR 139-181
   By Capt. Ernest D. Peek, Corps of Engineers.
   - *United States Engineer Office Building, Canal Park, Duluth* 141
   - *Duluth Canal and Aerial Bridge* 153
   - *Ore Docks of Great Northern Railroad, Allouez Bay* 159
   - *One of the many coal docks, Superior Bay* 159
   - *Grain Elevators on Superior Bay* 163
   - *Duluth Canal Piers* 171
   - *Superior Entry; viewed from lake* 173
   - *Superior Entry; viewed from harbor basin* 173
   - *Superior Entry; inner end north concrete canal revetment* 175
   - *Superior Entry; north breakwater with concrete pier-head* 177
   - *Superior Entry; north breakwater, looking toward lake* 177
   - *Superior Entry; north breakwater under construction* 179
   - *Superior Entry; outer end north canal revetment* 181
2. THE MODERN SIEGE 182-221
   By Capt. E. L. Daley, Corps of Engineers.
3. THE NEW WELLAND SHIP CANAL 222-227
   Reprinted from *The Canadian Engineer*, August, 1913.
4. ON WHAT BASIS SHOULD RECOMMENDATION FOR A WATERWAY IMPROVEMENT BE MADE? 228-231
   By Maj. George P. Howell, Corps of Engineers; M. Am. Soc. C. E.
5. GEN. CHARLES WALKER RAYMOND (See Frontispiece) 232-235
   By Brig. Gen. Oswald H. Ernst, Corps of Engineers; M. Am. Soc. C. E.
6. CONCRETE AND METAL FENCES 236-241
   By Mr. Frank D. Holbrook, Assistant Engineer; M. Am. Soc. C. E.
   (With Cost Data by Lieut. Jarvis J. Bain, Corps of Engineers.)
   - *Fence at Dam No. 15, Ohio River* 237
   - *Galvanized wire fence with concrete posts, Georgetown Reservoir* 238
   - *Concrete and steel fence at Georgetown Reservoir* 239
   - *Concrete guard fence, Conduit Road; Washington Aqueduct* 241
7. COST OF GOVERNMENT DREDGING *v.* CONTRACT DREDGING 242-243
   By Lieut. Col. Harry Taylor, Corps of Engineers; M. Am. Soc. C. E.
8. NOTES ON RIVER AND HARBOR WORKS 244-249
   - Dredging at Pinole Shoal, San Pablo Bay, California 244
   - Lock Gates for the Ohio River Locks 245-246
   - Cascades Canal, Columbia River, Oregon 246-249
   - *Dredging at Pinole Shoal, San Pablo Bay, California* 245
   - *Gate recess, Ohio River lock, during construction* 247
   - *Cascades Canal and Locks, Columbia River, Oregon* 249
9. MAXIMUM FLOOD DISCHARGES 250-255
   Staff Article.
   - *Diagram showing rate of maximum flood discharge* 251
10. LIGHT BRIDGE EQUIPAGE 256-268
    By Capt. W. G. Caples, Corps of Engineers.
11. BOOK REVIEWS 269-271
    - Technique of Modern Tactics 269-270
    - Essais sur la Guerre Russo-Japanaise 270-271
12. EDITORIAL NOTES 272-274
    - Failure of the Stoney River Dam 272-273
    - Bibliography of the Mexican War 273-274
    - Erratum 274
13. SELECTED ARTICLES OF ENGINEERING INTEREST .... viii-xiii
    Compiled by Mr. Henry E. Haferkorn, Librarian, Engineer School.

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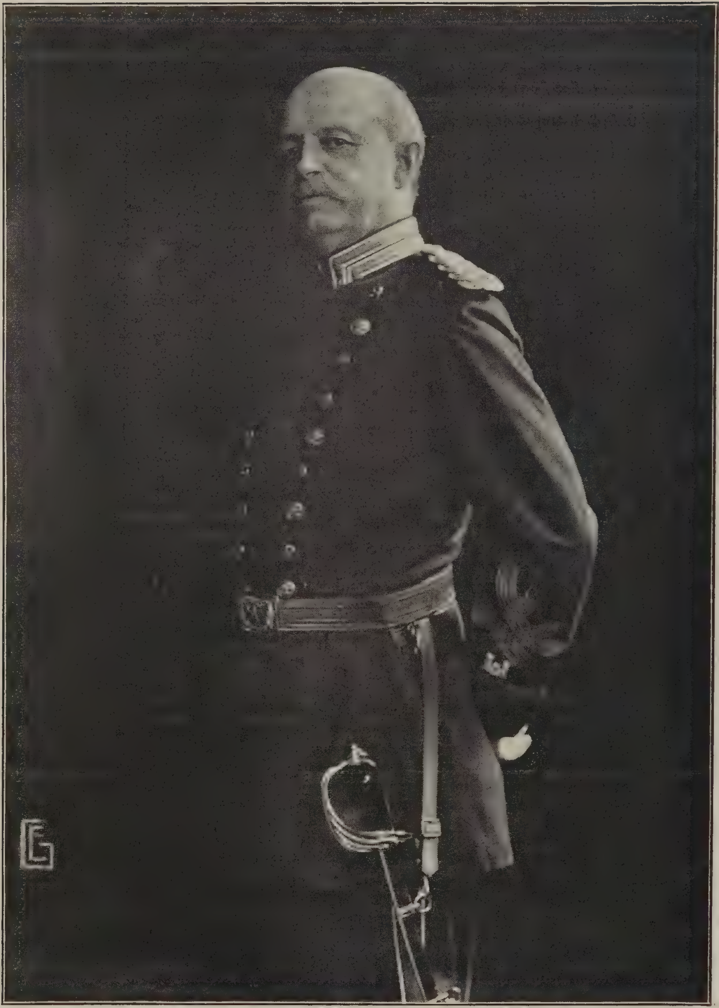


GEN. CHARLES WALKER RAYMOND

CORPS OF ENGINEERS, UNITED STATES ARMY

BORN 1842—DIED 1913

SEE PAGE 232

Duluth-Superior Harbor

BY

Capt. ERNEST D. PEEK
Corps of Engineers

LOCATION.

Duluth-Superior Harbor, situated at the extreme westerly end of Lake Superior, is the joint harbor of the two cities; Superior, with 40,000 inhabitants, founded about sixty years ago, is in Wisconsin, while Duluth, a younger city chartered in 1870, with 80,000 inhabitants, lies just across the St. Louis River in the State of Minnesota. They are usually called the ''Twin Ports'' at the head of the Great Lakes.

TERRITORY COMMANDING.

Its location makes it a veritable distributer of the rich iron deposits in the immediate vicinity, and of the enormous agricultural products grown in the vast expanse of territory lying to the west and northwest. The territory which is naturally supplied by Duluth-Superior is all that portion bordering on the Great Lakes; it is the starting point for water travel to the east and other lake ports, and also the greatest receiving port for supplies which must come in return to the territory from which were received the vast quantities of iron ore and grain.

On account of the excellent location given it by nature, it has the most commanding position for commerce and shipping of any city in the world not situated on the high seas. It is at the head of the deep-water route to Buffalo and intermediate points, the distance being 985 miles, the capacity of which route is limited only by the locks at Sault Ste. Marie. Shipments are also made directly to Europe, the size of vessels being limited at present by the capacity of the Welland Canal.

PHYSICAL CHARACTERISTICS.

This harbor, with an area of more than 19 square miles, is composed of a group of enclosed and naturally protected bodies of water known as Superior Bay, Allouez Bay, St. Louis Bay, the expanse of the lower portion of the St. Louis River just above St. Louis Bay and the two entrances, Duluth Canal and Superior Entry. These bodies of water are separated from the open water of Lake Superior by a natural "spit" of sand, or sand-barrier, which forms a most advantageous breakwater. This barrier is about 10 miles long, lying less than 1 mile from shore, and originally had a shallow opening through it about half a mile wide which provided an outlet for the discharge of river waters. North of this natural opening, called Superior Entry, the barrier is named Minnesota Point, and south of this entrance Wisconsin Point.

These barriers of sand and gravel, principally formed by the action of waves upon the shallow bottom of the lake, are augmented by the movement of material from the adjoining shores of the mainland, known as littoral drift. Similar barriers are found at other localities on Lake Superior; for example, at the head of Bark Bay on the south shore, at Big Bay on the east side of Madeline Island, and at Chequamegon Point near Ashland.

As to the origin of the natural harbor of Duluth-Superior, it is thought that it came as a result of a series of developments or evolutions, and that at one period of its history Lake Superior extended up the St. Louis River to the vicinity of Fond du Lac, some 20 miles from Minnesota Point.

The first change was a cutting-off of the St. Louis River by sands being washed up, forming Grassy Point and making an enclosed basin of that portion of the upper St. Louis River; the second change was when the lake washed sands farther to the east in the vicinity of Rices Point and Connors Point and enclosed St. Louis Bay as a harbor; then the third stage, when the action of the lake formed Minnesota Point and Wisconsin Point and made the present harbor.

These suppositions and theories are not unreasonable, for the high lands, showing the once general form of the lake, extend along both banks of the St. Louis River, coming together near Fond du Lac. All soils surrounding the city of Superior, which is very flat, and above to the higher ground, are of a sedimentary character and show deposit of one kind or another.

The foundation laid here by nature for a harbor has been supplemented by artificial improvements which have consisted chiefly in deepening and protecting the natural entrance, constructing a second entrance, deepening the interior basins to accommodate the larger class of vessels, rectifying the channel of the St. Louis River, and establishing a system of harbor lines. An outline of the various projects under which this work of improvement has been in great part accomplished is given in another part of this article.

HISTORY.

Superior Entry, the natural outlet into Lake Superior from Superior Bay, the harbor proper, lies between Minnesota Point and Wisconsin Point. As early as 1868 an examination was made by Lieut. Col. W. F. Reynolds, Corps of Engineers, who recommended the construction of two parallel piers 2,000 and 3,000 feet long, respectively. In August, 1867, Henry Bacon, Assistant Engineer, recommended that an artificial channel should be built across Minnesota Point about 1½ miles to the north of the Entry. The improvement of this natural channel by the Government was begun in 1868, when Duluth was a city of some half-dozen families; in

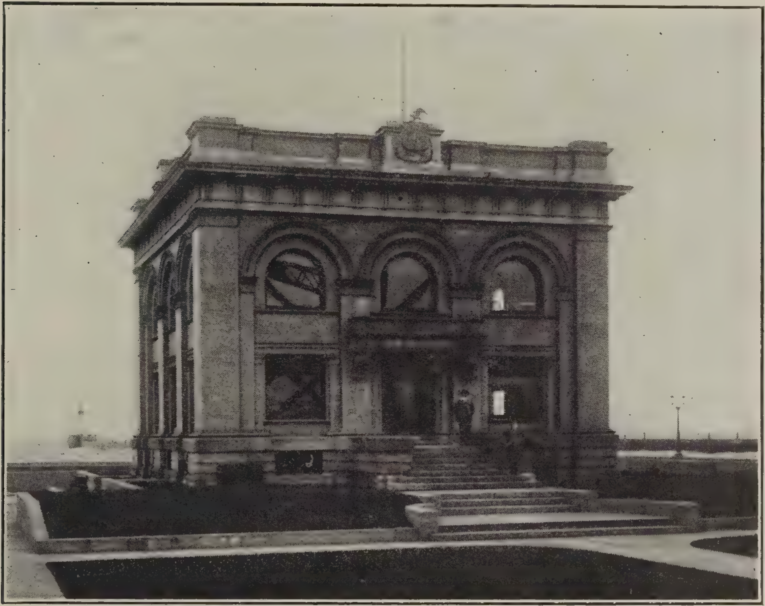


Fig. 1. Duluth. U. S. Engineer Office Building, Canal Park.

the next year a survey of Duluth Harbor was made and the following plans submitted:

First. To construct a breakwater in the lake, 1,200 feet long, east of Minnesota Point and extending into the lake in a direction generally parallel to Minnesota Point.

Second. By cutting a canal through Minnesota Point, opposite Rices Point, and building parallel piers.

Third. By using Superior Entry, and dredging out a basin at Duluth and a channel through Superior Bay.

The second plan was recommended, but Maj. J. B. Wheeler, Corps of Engineers, in charge, stated that its adoption would injure the Superior Entrance then being improved; that the commerce of Duluth did not warrant the first, so he recommended the third plan—the use of Superior Entry, with the dredging of a channel and basin.

In spite of these recommendations, the city authorities of Duluth and the railroad interests combined, and, in the fall of 1869, began the construction of a breakwater extending into Lake Superior as outlined in the first plan. In the fall of 1870, the council of the city of Duluth decided to build a canal 150 feet wide, 16 feet deep, and protected by piers on each side to 18 feet of water in the lake at the present site of the Duluth Canal.

Duluth realized that to be a harbor of consequence she must have rail connections, and the first train of cars from St. Paul reached Duluth on August 1, 1870, over the Lake Superior & Mississippi Railroad. At this time the Northern Pacific Railroad, building to the Pacific Coast, was desirous of obtaining a good harbor on the lake, and cooperated with the city of Duluth in the construction of the canal. It was begun in the fall of 1870; in the following spring the cut was opened, the waters connected, and Duluth found herself with a beautiful harbor and her own entrance. However, as early as September, 1870, complaint was made by the city of Superior and the State of Wisconsin that the canal would ruin the natural entrance at Superior by diverting the waters which were necessary for preserving it. This was the first of a series of actions at law which resulted in Duluth being required to build a dike across Superior Bay from Rices Point to Minnesota Point. It was built to prevent the waters of St. Louis and Nemadji rivers from flowing into Lake Superior through the Duluth Canal.

This dike was completed March 25, 1872, and on June 20 of the same year the citizens of Superior, in the name of the State of

Wisconsin, filed a bill in equity in the United States Courts against the city of Duluth and the Northern Pacific Railway Company. It alleged that the dike was a nuisance and deprived the citizens and inhabitants of Wisconsin of an easement and right of way over the whole of St. Louis River and the navigable waters leading into same. This action resulted in the dike remaining, but with an opening being made, in 1877, sufficiently large to permit free navigation, and allowed the people of Wisconsin to enjoy their easement in the waters of Duluth Harbor. The work continued to stand, very much dilapidated, until 1896, when the Government considered it a menace to navigation and removed it.

From September, 1870, when the first legal step was taken against Duluth and its canal, until the decision of the Supreme Court in 1877, it was a legal battle involving great expense, together with the cost incurred in the construction and maintenance of an unnecessary dike more than a mile long across Superior Bay.

After the decision of the courts in 1877, Duluth was no longer molested by Superior, and both Duluth and Superior each received appropriations from Congress for its own harbor up to and including the appropriations of August 18, 1894. Previous to 1894 we have Duluth-Superior comprised of two individual harbors with no object in common, each the rival of the other, and each striving to obtain all benefits to itself. In 1893, the policy of the two cities was changed, and a harbor committee, composed of both Duluth and Superior citizens, was organized to build up the port of Duluth-Superior as one harbor.

By the act of Congress approved June 29, 1884, the future of Duluth-Superior was to be projected by a Board of Engineers, and by the act approved June 3, 1896, the harbors of Duluth and Superior were unified and provided for by continuous contracts for their improvement. By the continuous-contract system a saving of at least 40 per cent was undoubtedly made. It was a sound, business-like proposition; it was on a plan that was broad and comprehensive and calculated to meet the requirements of commerce for many years. Since this unification Duluth-Superior Harbor has progressed and developed beyond all expectation, and all has been for a common cause.

DEPTHS.

Before the improvements were begun, the broad bays had a depth varying from 8 to 9 feet; however, in the channel, which was very variable, the depth was greater. The natural entrance had a depth of 9 to 11 feet, with a very winding channel and a shifting sand bar just outside. The Duluth Canal, being artificial, did not exist prior to improvements being undertaken.

CURRENTS.

The currents in the deep water of Lake Superior and along its shores are not ordinarily strong, and in the vicinity of Duluth-Superior seldom reach a velocity of more than one-third of a mile per hour. The current, which exists at times along the north shore, flows to the west and then south past the Duluth Canal and is neither strong nor regular. On account of the rocky character of this shore and the deep water, these currents carry but very little sediment.

At the Superior Entry we have the current generally flowing in a westerly direction along the south shore of the lake and then north past the Entry; this current carries considerably more sediment, due to encountering a different character of material than found on the north shore of the lake. The great amount of this sediment is evidenced by the building up of the shore south of the south pier of Superior Entry. On account of the very small currents generally prevailing in the vicinity, it is sometimes believed that the greater portion of the increase in shore line is due to the wave action washing the sand along the shore and that the current carries only a small portion of this material. As the majority of waves strike the shores at an angle, they have a component force parallel to the shores which tends to carry the sand along the shore. As the prevailing winds are from the northeast, they would cause waves to be formed which would have such action.

As to the rate of advance of the shore line along the south pier, an accurate estimate may be had from the following table:

Years.	Period.	Shore advanced.	Rate per year.
	Years.	*Feet.*	*Feet.*
1856-1873	17	270	15.9
1873-1879	6	510	85.0
1879-1884	5	165	33.0
1884-1894	10	195	19.5
1894-1897	3	30	10.0
1856-1897*	41	1,170	28.5

*Average for entire period.

This is a total advancement of 1,170 feet in forty-one years. Since 1897 little or no increase has occurred, due to the new work and dredging for the improvement being carried on by the Government. This work will be completed in 1914, when there will probably again be an advance in the shore line until a point of equilibrium is reached between the currents and the new deposits which will result on account of the improvements.

From the preceding table it is seen that the yearly rate of advance decreases during each successive period, except for the first period—1856 to 1873. The improvements at the Entry did not begin until 1868 and, as no record of the shore line for that year is available, it is believed that the rate of advance for the first period does not give a reliable average, as the interference of the piers to the current is only for the last three or four years after the commencement of the work. The true rate of advance after the earlier work was completed is possibly five or six times as great as the average rate, because the work obstructed the current entirely for only a portion of the four years of the seventeen years averaged. Now that the new work is about to be completed, it is expected that there will be an increase in the rate of advance over the last yearly advance of 10 feet, on account of the new work extending out so much farther and destroying the equilibrium, which had been nearly reached.

None of the currents in St. Louis Bay are strong enough to interfere with navigation interests. In both of the entrances we find currents of various degrees of strength; these are due principally to oscillations in the level of the lake, which fluctuates several times each day, causing the current to flow into or out of the harbor as the lake happens to rise or fall. The length of time that the current flows in one direction depends upon the length of period of the oscillation if its time is short; and if the period is long then upon the time necessary to raise or lower the level of the harbor to that of the lake. These currents are very irregular, both as regards length of time that they may flow in one direction and as to velocity of flow. On rare occasions, the currents have reached a velocity of 6 miles per hour in one direction and followed shortly by a reverse current equally as strong. Ordinarily, the current does not exceed 2 miles per hour or 3 feet per second.

The combined volume of waters of the St. Louis and Nemadji rivers would create in Superior Entry a current with a velocity of approximately .9 foot per second, but the volume of water flowing in and out of the Duluth Canal and Superior Entry is more than six times that amount. This shows what a small effect the river waters have on the entrances, as most of it comes from seiches in the lake, except on very rare occasions when the St. Louis River is at a high flood stage. These periods of high flood ordinarily range with an interval of from seven to nine years, though there has been none since the year 1897. During the flood periods of the river, the currents in the Duluth Canal reach a velocity of from 4 to 7 miles per hour and continue, as a rule, for several days. The currents in St. Louis Bay are evident only during high water in the St. Louis River, when the stream empties its waters through Superior Bay and the Duluth Canal. Superior Entry receives but little if any of the flood waters, due to the fact that the Duluth Canal lies nearer to the junction of the river and St. Louis Bay and provides an increased slope of water surface. The changes in direction of current in the Entry and the Canal are, on the one hand, a benefit to the harbor, as they prevent or delay the formation of ice at the entrances for nearly the entire winter; and, on the other hand, an outgoing current, when it meets a heavy sea from the northeast, increases the height of the waves, tends to form a choppy sea and increases the dangers and difficulties for vessels entering. Only occasionally, when the currents are very strong, are they an inconvenience to navigation. The velocities of currents in Superior Entry are a little less than the above figures taken in the Duluth Canal, due to the fact that the length of the channel between the piers is greater, so that the slope of the water surface resulting from any oscillation is less.

Three cases have been reported of vessels being thrown against the piers when there was a strong current and a high sea during exceptional storms. In ordinary weather, the danger due to this cause seems to be very small, for vessels seldom fail to clear and do not appear to hesitate on that account.

VARIATIONS IN WATER LEVEL.

One of the principal commercial advantages of Duluth-Superior Harbor is that it does not have to contend with tides, which generally increase the difficulties of navigation and commerce in a harbor. Here the effect of the tide is practically nil, as it amounts to only a fractional part of an inch. Even though so ideally situated, it is subject to changes of water elevation, as Lake Superior is continually undergoing some fluctuations of levels. These fluctuations are in part changes in the entire lake level and in part local changes of a temporary character.

SEASONAL CHANGES IN LEVEL.

Owing to the melting of snow in the spring and the rainfall during the open season, the absence of rain in the winter, when the precipitation consists entirely of snow which does not at once find its way into the streams and lake, and to the fact of the swamps and streams becoming more or less frozen up in the winter, the lake surface passes annually through a cycle of changes which is quite regular in its period. The average range or amplitude of this change is about 1 foot. The maximum elevation always occurs in August or September and the minimum in March or April.

CHANGES CAUSED BY WIND.

The wind acts upon the surface of a body of water by pressing against the rear side of the waves, and produces a surface current with a very moderate velocity moving in the direction of the wind. Such a current was observed in the vicinity of Duluth during a northeast gale of moderate force and found to have a velocity of one-half foot per second or one-third mile per hour. As a result of this wind pressure and surface current, the surface of the lake is raised to some extent along the windward shore and depressed along the leeward shore. Accordingly, at Duluth the surface rises during a northeast storm and is depressed during a westerly or southwesterly storm. The amount of this change ranges from a few inches to a foot or more, depending on the strength of the wind and its fetch.

The resulting effect of the wind upon the water level is less in the case of a deep body of water than in a shallow one. This is probably due to the greater depth, permitting more free movement of the return subcurrent or undertow, which tends to decrease the piling-up effect; thus on Lake Erie, a shallow body of water, the rise of the lake surface on the leeward shore is much greater than on the deep water of Lake Superior, amounting to about 6 or 7 feet at Buffalo during a severe westerly wind. This rise of 6 or 7 feet at one end of Lake Erie, and a corresponding lowering at the other end, produces a difference of over 13 feet in lake level between the extremities. One particularly severe storm raised the water at Duluth only 2.2 feet.

SEICHES.

Many fluctuations in the harbor are not due to winds, for we have changes during quiet weather and also during the winter months, when Lake Superior is covered with ice as far as the eye can see. When ice is present the wind can not exert a direct force upon the water; nevertheless the level rises and falls and currents continue to oscillate through the canal and entry.

The term ''seiches'' is applied to these temporary and brief movements of the surface, which sometimes occur during calm and in winter even during windy weather. At Duluth the water has been seen to rise a foot or more, then, after a few minutes, fall to about the same distance below the mean level and repeat these oscillations with diminishing amplitude. Once the observed range at the Duluth Canal from maximum to minimum was 4 feet. Seiches are supposed to be due to sudden variations in atmospheric pressure at some point on the lake, probably a partial vacuum at the center of a local rotary storm of cyclonic type, in which case the lake surface would rise to balance the diminished pressure and afterwards fall. These oscillations propagate long tidal waves or swells, which travel radially to other portions of the lake.

ANNUAL CHANGES.

Owing to the variation in rainfall and rate of evaporation, the mean level of the lake fluctuates from year to year. Sometimes a fall in level will continue during several years, followed by a more or less rapid recovery and movement to a higher level; for example, in 1872-1876, the mean level of the lake increased each year during the four years from +0.28 in 1872 to +1.31 in 1876, then fell during the next three years to —0.32. It then took another turn and rose during the next two years to +0.46 in 1881. After this it remained nearly stationary for a number of years.

SECULAR CHANGES.

The records for the elevations of Lake Superior date back to the year 1860, and indicate no permanent changes or any tendency to a higher or a lower level.

CHANNELS.

No channels in either Superior Entry, Superior Bay, or up the St. Louis River were originally of sufficient depth to accommodate the traffic of to-day. The present depth has been projected for vessels of 20-foot draft with a 22-foot depth of water. The old channel in Superior Bay, leading from Superior Entry to the mouth of St. Louis River, was very winding and has been entirely abandoned; the new channels were laid out and constructed so as to accommodate the present established harbor lines.

SHOALING.

The only tendency to shoaling in the lake at the mouth of the Duluth Canal results when outgoing currents reach deep water and permit sediment, which is being carried, to fall to the lake bottom. This shoaling is not very great, but that which is deposited falls within a distance of some 900 feet from the mouth, leaving none in the channels of the entrances. These deposits in the lake consist mainly of sand picked up by the scouring action of the currents in passing out between the entrance piers. It has been estimated that only one-third of the material between the Duluth Canal piers was excavated or removed by dredging and that the remaining two-thirds was scoured out by the currents. A comparatively small amount of scour has occurred during the past few years, tending to show that equilibrium between the scour and the depth of the canal is being approached.

No definite results or estimate can be found of the scour and shoaling at Superior Entry, due to the fact that a portion of the old south pier, which is now being removed, still remains in the entrance channel.

Within the bay we find the St. Louis and Nemadji rivers; the sediment of the former is negligible save at periods of high floods, once in from seven to nine years. The territory through which it flows, except the last 20 miles from Fond du Lac to Superior Bay, is rather rocky, so the quantity of sediment carried by that stream is limited; then, again, this stretch of 20 miles permits whatever sediment is carried to be deposited well upstream, as this portion is practically slack water.

The Nemadji, on the other hand, is subject to annual freshets, and flowing through an alluvial country readily accumulates sediment, which forms shoals each year at its mouth in Superior Bay. This shoaling, though not ordinarily heavy, requires some dredging each spring. Shoaling, caused by sediment being carried by currents or washed along the lake shore, has been discussed under currents in a preceding paragraph.

WINDS.

From the records of the United States Weather Bureau, covering a period of forty-two years in this harbor, there has been compiled the following information:

Data on Winds.

	Prevailing wind.	Mean hourly velocity	Max. velocity.	Direction.
January, 1909	S.W.	14.1	71	N.W.
February, 1909	N.W.	14.2	60	N.E.
March, 1878	N.E.	14.4	62	N.E.
April, 1912	N.E.	14.7	70	N.W.
May, 1877	N.E.	14.8	60	N.E.
June, 1904	N.E.	11.8	63	N.E.
July, 1907	N.E.	11.4	56	N.W.
August, 1904	N.E.	11.5	51	N.W.
September, 1881	N.E.	12.6	78	N.E.
October, 1909	N.E.	13.6	58	N.W.
November, 1905	S.W.	13.8	70	N.W.
December, 1904	S.W.	14.1	65	N.W.

From observations of the last five years, the following is derived:

Wind Movements.

Year.	Miles per hour.	Total miles for year.
1908	13.6	119,437
1909	13.2	115,752
1910	13.2	115,179
1911	13.4	117,317
1912	12.7	111,660
1908 to 1912, inclusive*	13.4	115,469

*Average for five years.

Frequency of Winds.

Direction	N.	N.E.	E.	S.E.	S.	S. W.	W.	N.W.	Calm.
In percentages	4.7	28.6	3.4	2.4	2.8	17.2	19.9	20.7	.3

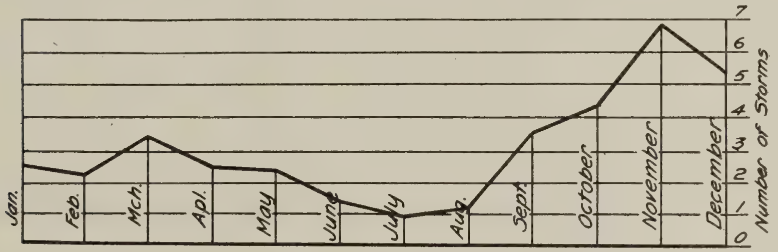
The number of 40-mile gales on Lake Superior during the period 1908 to 1912, inclusive:

1908	43
1909	47
1910	27
1911	41
1912	27
Total	185

Average per year for the last five years, 37 per annum.

The illustration below shows relative frequency by months of 40-mile gales on Lake Superior.

From the foregoing data, it is seen that the prevailing wind for eight months of the year is from the northeast, which period covers practically the entire navigation season. (The mean direction is, however, N. 50° E.) The northeast is the direction which has the longest fetch, 200 miles or more, and is the principal reason that Lake Superior is so hard to navigate. Taking into consideration the wind velocity, approximating 20 miles per hour, northeasters frequently cover two to three days and sometimes longer, although at times the high velocity averages but twelve hours duration per storm. There have been numerous departures from the latter rule, the one most notable being the extreme northeast gale of November 27-28, 1905, when the steamer *Mataafa,* later described in this article, went ashore at the mouth of the Duluth Canal.



In this instance, the following averages were obtained: 25 miles or more per hour for twenty-nine hours, the average velocity 42 miles; an average range from 50 to 60 miles per hour was obtained for fifteen hours, and of 60 miles and more per hour for about thirteen hours. The maximum velocity of 66 miles per hour (fifteen-minute periods) occurred in each of eight hours, and of 68 miles in each of two hours.

The one feature of a northeast storm that is favorable to navigation is that it ordinarily blows steady and strong, even though for a long period. It is of a different character than a west wind, which is puffy, squally, and probably only of a duration of three-fourths of an hour to one hour, and seldom over three hours. Naturally, a wind from the west has not a very injurious effect on a harbor like this, as it is an off-shore wind; however, its effect as one departs down the lake increases with the distance.

From the illustration showing frequency of 40-mile gales by the months, it appears that fewer gales occur during the months in the navigation season, except for the month of November. Ordinarily, navigation extends only until the 1st of December, so that only a portion of the worst storms are met with during the season.

WAVES.

As a result of northeast winds having a fetch of 200 miles or more, the resulting waves at the entrances to the harbor reach a considerable height. During the seasons of 1901 to 1903, Col. D. D. Gaillard, Corps of Engineers, when in charge of the Duluth District, made a very extended study of wave action in this locality, and the results are published in Professional Papers No. 31, Corps of Engineers. The observations were taken with a view to determine the height, length, velocity, and dynamic force of the waves. The result of these two thousand or more observations showed that the greatest storm waves range in height (hollow to crest) from 14 to 23 feet, in length from 200 to 275 feet, and with a velocity of propagation of from 25 to 33 feet per second. As these observations were made at the entrance in shallow water, it is reasonable to assume that waves in the open lake were even greater. The maximum recorded pressure from wave impact, obtained by the use of spring dynamometers at Duluth-Superior, was 2,370 pounds per square foot.

The highest waves recently observed in the Duluth Canal were on November 28, 1905, when the crest of the wave was observed to reach a height of 20 feet above low water datum at the south pier of the Duluth Canal. The water level at that time was not more than 3.8 feet above low water and might have been zero, as the water level was changing very rapidly during the storm. The height of the top of the wave above the water level was between 16.2 and 20 feet, which would be a wave of from 26 to 30 feet in height from bottom of trough to the top of the wave.

The axis of the Duluth pier is within 15 degrees of the direction of prevailing northeast winds, and that of Superior Entry within 5 degrees. Even though Lake Superior is subject to heavy seas, the harbor lies so that the axes of the entrances could be constructed as to practically coincide with the direction of the prevailing wind. The benefits to be derived by mariners are self-evident, as it gives little or no cross effect of the winds upon ships in entering or leaving the harbor. The confidence which masters

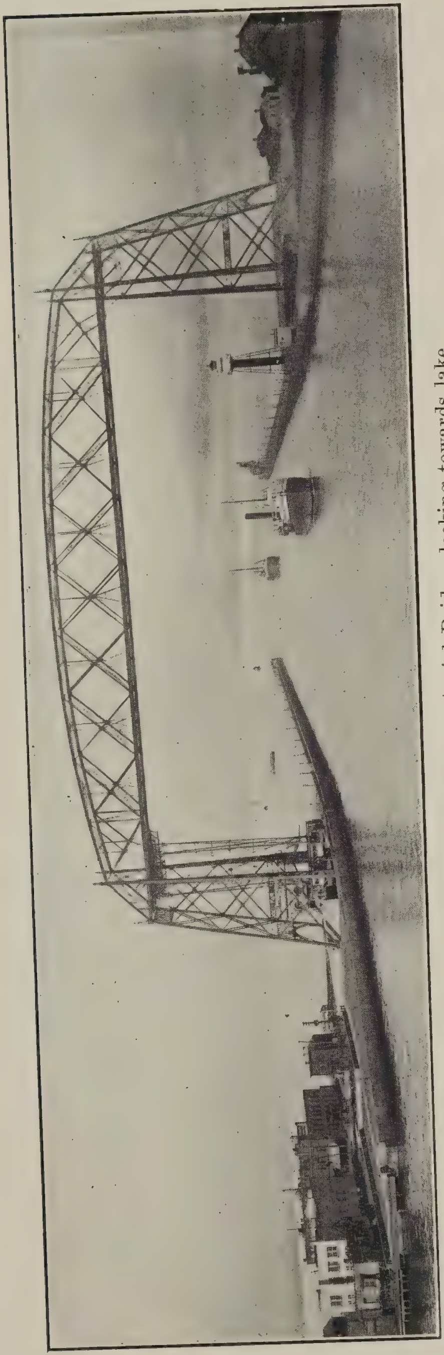


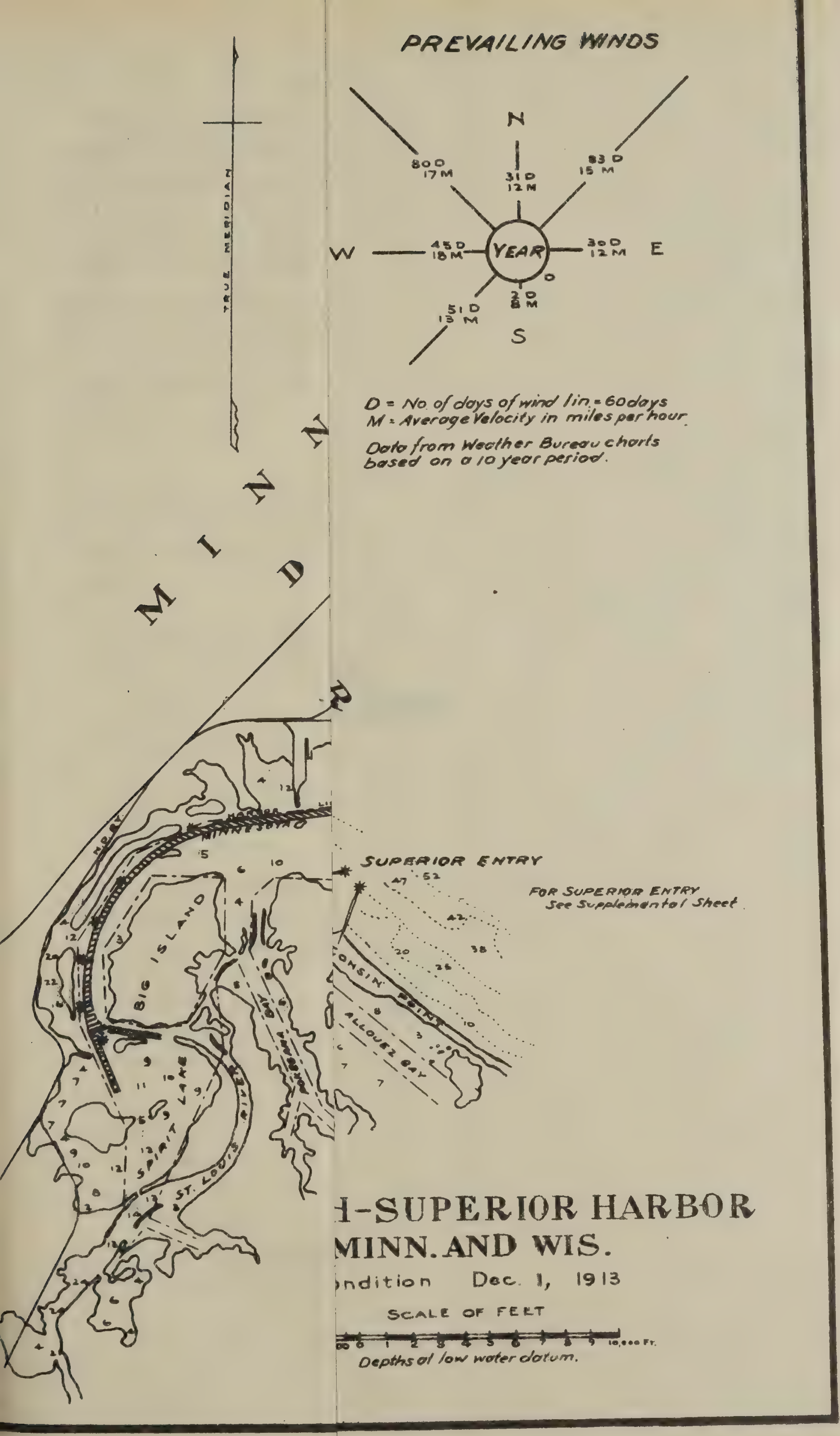
Fig. 2. Duluth Canal and Aerial Bridge, looking towards lake.

have to make an entrance or to clear from this port is evidenced by their moving through the entrances in all kinds of weather. This fact is even the more remarkable when one considers that the large freighters, over 600 feet in length, are equipped with only a single propeller.

The piers of the Duluth Canal extend into water of 20-foot depth. The channel between the piers has a depth of from 26 to 43 feet, which is carried out for 900 feet across the lake bottom with a depth of 32 feet.

The regulations for this harbor permit vessels to enter and leave between the piers at any speed, which, in the case of large vessels, would require an extra depth of water to provide for the increased draft or ''squat'' of nearly 2 feet, so that vessels drawing 20 feet at the dock would draw approximately 22 feet under way.

Since the present entrance piers at Duluth have been completed, there has been only one serious wreck resulting in loss of life. This occurred on November 28, 1905, when the steamer *Mataafa,* 430 feet long, was broken on the shore east and north of the Duluth piers with the stern of the boat lying against the north pier. The day this boat entered the wind was blowing strong from the northeast and had caused a rise in the water level in this harbor of approximately 2.5 or 3 feet, with waves rolling at least 20 feet in height. The vessel had also been shipping considerable water through her hatches, so that she was drawing probably 23 feet when under way. At the time of the accident, the depth of water in the channel and to some distance beyond the outer end of the piers was only 29 feet. Many vessel men and others claim that the vessel was wrecked due to striking the bottom with the bow when her forward portion was in the trough of a wave, this impact so checking her speed that the wind blew the stern around so that control of the ship was lost and she rammed the outside of the north pier and was blown up on shore. From the above discussion with the various depths as given this might not have been an impossibility, yet not probable, had the vessel not lost headway. It was observed that the ship lost her momentum just before reaching the canal, which might have lessened her squat somewhat, though perhaps not over 1 foot. As to slacking the speed, some argument has been advanced whether this was due to the checking received by striking, or the stopping of the engines by the captain losing his nerve, or through an error in signals, which point has never been satisfactorily determined.



PREVAILING WINDS
N
S
E
W
YEAR
80 D 17 M
31 D 12 M
83 D 15 M
45 D 18 M
30 D 12 M
51 D 13 M
2 D 8 M
0
TRUE MERIDIAN
M I N N
D
R
MINNESOTA
SUPERIOR ENTRY
BIG ISLAND
SPIRIT LAKE
ST. LOUIS
ST. LOUIS RIVER
ALLOUEZ BAY
WISCONSIN POINT
BAY
47
52
42
38
20
26
10
5
6
10
4
12
22
9
11
7
8
13
3

D = No. of days of wind 1 in. = 60 days
M = Average Velocity in miles per hour.

Data from Weather Bureau charts based on a 10 year period.

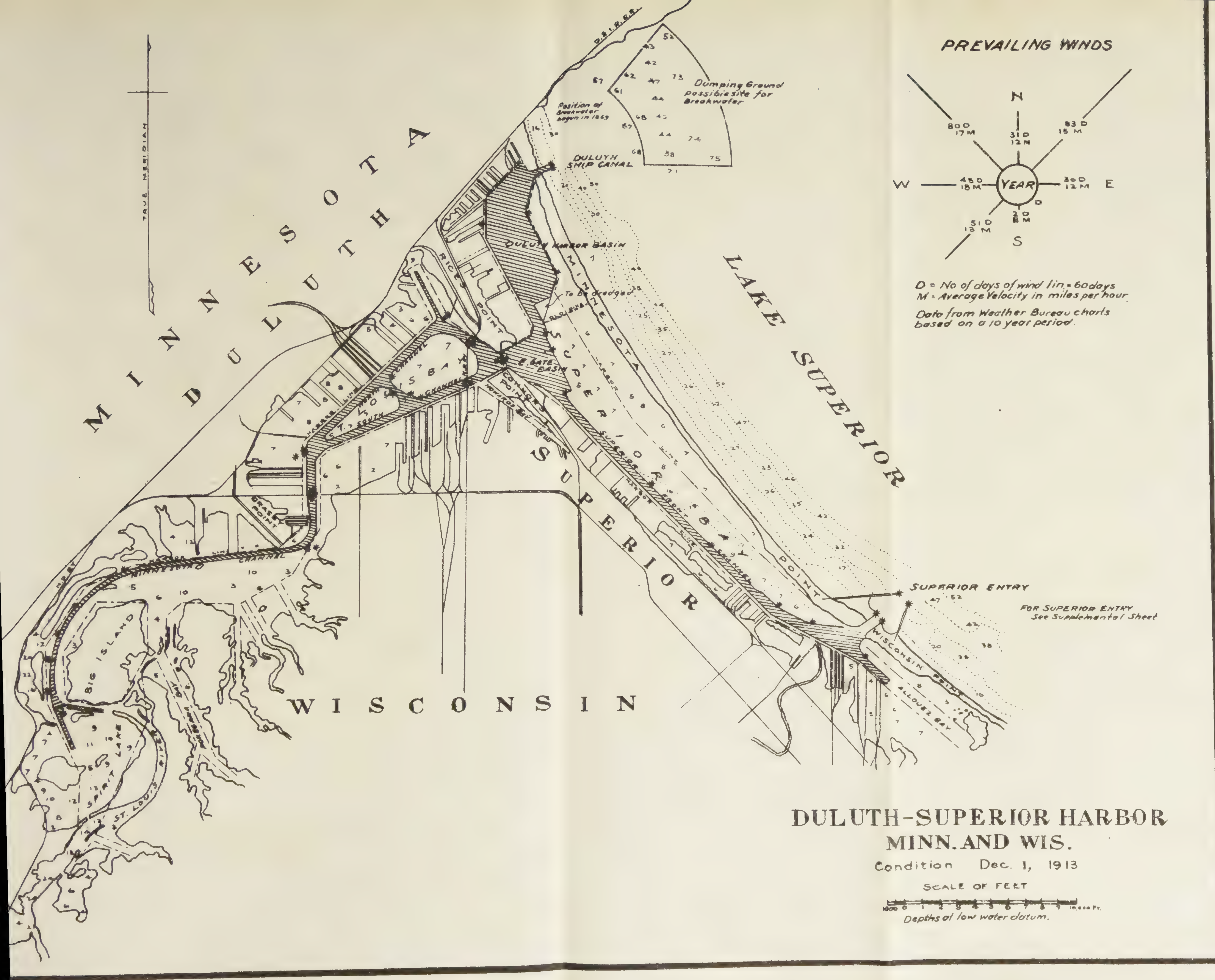
FOR SUPERIOR ENTRY See Supplemental Sheet

-SUPERIOR HARBOR
MINN. AND WIS.
ndition Dec. 1, 1913

SCALE OF FEET

00 0 1 2 3 4 5 6 7 8 9 10,000 Ft.

Depths at low water datum.



PREVAILING WINDS
N
S
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MINNESOTA
DULUTH
LAKE SUPERIOR
WISCONSIN
SUPERIOR
TRUE MERIDIAN
D. & I. R. R. R.
Dumping Ground possible site for Breakwater
Position of Breakwater begun in 1869
DULUTH SHIP CANAL
DULUTH HARBOR BASIN
To be dredged
MINNESOTA POINT
RICES POINT
ST. LOUIS BAY
E. GATE BASIN
CONNORS POINT
SUPERIOR BAY
SUPERIOR ENTRY
FOR SUPERIOR ENTRY See Supplemental Sheet
WISCONSIN POINT
ALLOUEZ BAY
GRASSY POINT
BIG ISLAND
SPIRIT LAKE
ST. LOUIS RIVER
MINNESOTA CHANNEL
HARBOR LINE
SCALE OF FEET
Depths at low water datum.

DULUTH-SUPERIOR HARBOR
MINN. AND WIS.
Condition Dec. 1, 1913

It appears that European authorities give more weight to extra depth of entrance as may be needed for squat, pitch, and diminished depth due to waves than American authorities, and it might be well for us to appreciate more the possibilities of accidents due to these causes. As regards the above discussion of the accident, the author does not admit that the wreck was caused by the vessel striking the bottom, losing headway and swinging across the north pier, yet he does admit there is ground for argument for this belief. The increase in depth beyond the piers was not made until the year following the above accident, when it was increased from 25 to 30 feet.

COMMERCIAL.

The following railroads entering this harbor have, with their allied systems, a combined mileage of 39,234.5 miles, and give resulting facilities surpassed by only two other cities in the United States.

	Miles.
Northern Pacific Railroad	6,297.2
Great Northern Railroad	7,484.1
Chicago, St. Paul, Minneapolis, & Omaha (Northwestern System)	7,960.5
Duluth, South Shore & Atlantic Railway and the ''Soo'' Line (Canadian Pacific System)	12,548.3
Duluth, Winnipeg & Pacific (Canadian Northern System)	4,316.6
Duluth & Iron Range	274.0
Duluth, Missabe & Northern	351.0
Interstate Railway	2.8

Water transportation is carried on by over sixty transportation lines, firms, or corporations, comprising both American and Canadian capital, owning and controlling hundreds of steamers, barges, and tugs. Of these, over six hundred different vessels visited the harbor during the year 1912, making the number of arrivals and departures at the two entrances for the year as follows:

	Entrances.	Departures
Superior Entry	1,699	2,029
Duluth Canal	4,419	3,699
Totals	6,118	5,728

The amount of freight shipped by water during the season of 1913 amounted to 47,000,000 tons, with a value of $352,000,000.

This tonnage is exceeded in the United States only by the city of New York.

The season for water transportation is, naturally, handicapped by the long period of winter. The open season ordinarily extends from April 15 or 20 to December 1, when vessel insurance is usually canceled, though many ships carry freight after that time and well into December, and small boats frequent the shores even into January. Though navigation begins about April 20, there are many times after navigation is opened that the harbor is blocked by ice at both entrances, and ships can not enter or leave until a change of wind. Often during May, after a heavy northeast wind, the ice packs to a depth of 20 to 25 feet, holding vessels fast only a few hundred feet from the entrance piers. On May 15, 1913, the ice was so heavy, and had been blown from all over Lake Superior to this harbor, that upwards of a dozen vessels were bound in the ice for seven hours. Ice at the entrance usually disappears by the first week of June, though its presence on July 4 is not improbable. Of course, no ice is in the harbor proper save that which may be carried in and out by the currents.

AREA.

The entire harbor covers 19 square miles. Of this area there are 11 square miles lying within the harbor lines and available for wharves and slips. This makes it by far the most capacious harbor on the Great Lakes. Within the harbor lines is sufficient room for 8 square miles of wharves or docks, besides the necessary slips. Of this space only about 1 square mile is now occupied by wharves, and 7 square miles of unoccupied space available for additional wharves. Harbor lines have been established by the Government, with an aggregate length of 49 miles, and Government channels dredged to accommodate the largest vessels along the front of the harbor lines wherever required by present or definitely prospective commerce.

Real estate on the present deep-water channels has risen to very high values, and there has been a constant cry of land owners to extend the deep-water channels farther up the St. Louis River. It would seem that in the not far distant future land on Minnesota Point will be used for wharves. Before this can be done, however, some means for providing rail connections must be had. This will involve a tunnel under the Duluth Canal or Superior Entry, or possibly a bridge from Rices or Connors Point to Minnesota Point.

Of course, the tunnel proposition will be far preferable to a bridge a mile long, though its cost will be very much more. Another objection to the long bridge would be the obstruction in the harbor basin and also the opening and closing of the bridge to the numerous vessels. The ground in which the tunnel would be built appears to be sand with gravel, as all the land on Minnesota Point is made ground. The subject of a tunnel was looked into a few years ago when the Soo Railroad purchased an entrance into Duluth, and at that time land holdings in the city proper had not risen sufficiently in price to warrant the undertaking.

It is thought that a tunnel under the Duluth Canal would not be as feasible as one under Superior Entry; the soil surrounding the former is similar to Superior Entry, though perhaps having more gravel. The land, however, has been built up with large warehouses, which would be a serious hindrance to an open-cut method of construction, whereas no interference of this kind would be found at Superior Entry. Land at Superior Entry is also cheaper and it would also have a longer approach than from Duluth, which would lessen any grade for entering the tunnel. When the time comes for using the frontage on Minnesota Point it will make 6 additional miles of water frontage available. No use of it is made at present on account of lack of rail connection.

Railway companies own the greater portion of the most accessible and convenient water frontage and have built terminals on some of this property. There remains a large extent of private-owned frontage occupied with terminals or available for terminals. The ownership of the harbor frontage is mixed. About 22 per cent of it is owned by railroad companies; less than 1 per cent by municipalities, and the remaining 77 per cent is owned by private individuals, companies, or corporations.

MUNICIPAL OWNERSHIP.

The city of Superior has acquired sites available for a passenger and general commercial wharf on Superior Bay and expects to acquire additional frontage, but as yet has not constructed terminals. The city of Duluth owns no harbor frontage, excepting street ends. A few years ago Duluth took up the problem of establishing municipal docks, but the prices of property were higher than it could afford to pay at that time and the matter was dropped before any results were accomplished. This matter is something which demands immediate attention on the part of the city. There are several methods that may be pursued, but Duluth needs first to make a beginning, as the delay is injurious to her shipping and has already practically driven out of business all package freight transportation lines on Lake Superior which were not controlled by the railroads.

New York City has been most successful in having municipal docks; Milwaukee and San Francisco have public ownership and management by State commission; Boston and Philadelphia have chiefly railroad and private ownership, while Baltimore with similar ownership is beginning municipal ownership. European ports are mostly publicly owned or managed by harbor trusts, which are closely allied to public ownership. Superior has not decided as to whether the revenue shall be derived by leasing a portion of its property outright, by charges based on tonnage of the boats, or the tonnage of the freight handled, or a combination of the latter two. All of these methods are in use in the large ports of this country and have been successfully managed.

Duluth, even with her lack of dockage and delay in obtaining the same, has advanced a new idea in that she believes water terminals for package freight and passengers should be owned and controlled by the Federal Government, which should also install modern machinery and appliances for handling the package freight. The argument advanced is that railroads owning freight lines, exclusive of those carrying bulk freight, desire not to diminish the rates, but wish to divert the boat traffic to the all-rail route. On this account they refuse to make the necessary improvements to reduce the charges for handling package freight, and, as no machinery at all is used in handling this commodity, this results in the freight rates continuing to rise as do the wages for labor.

EFFICIENCY.

The iron ore docks, coal docks and grain elevators are mostly of modern types and well equipped for the rapid handling of these commodities. Lumber is loaded into vesesls by hand. The methods of handling package freight, as stated above, are primitive and crude.

IRON ORE DOCKS.

Iron ore, the principal commodity, is loaded into vessels by gravity and requires but few mechanical appliances. Ore is brought from the mines in special cars holding about 50 tons, and these are

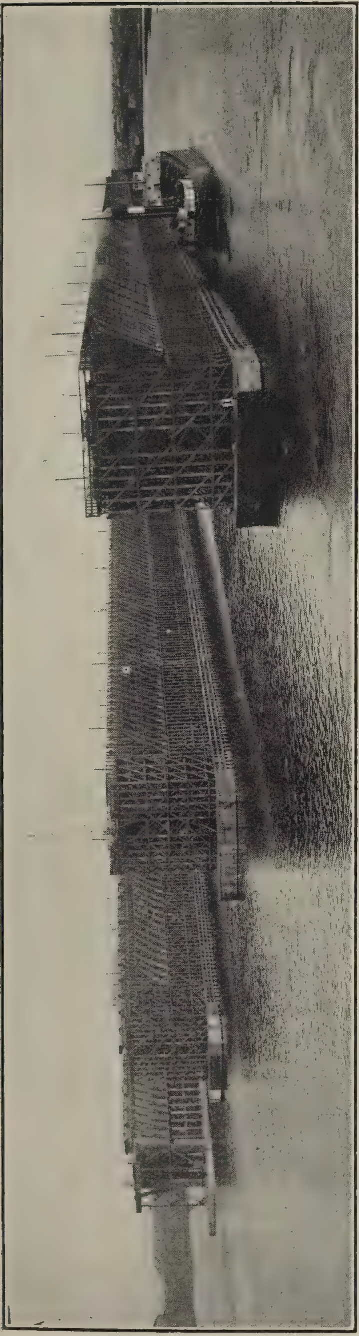


Fig. 3. Allouez Bay. Ore docks of Great Northern Railroad. Modern concrete-steel dock in background.

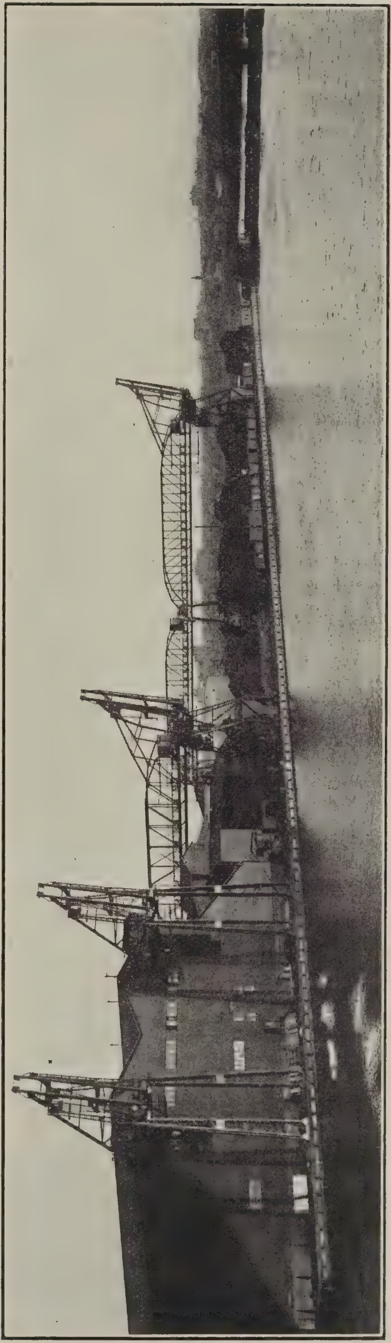


Fig. 4. Superior Bay. One of the many coal docks.

dumped through bottom doors into the ore dock pockets. From the pockets the ore runs by gravity into the hold of the vessel, provided with numerous hatches which enables it to receive ore from many of the pockets at once. A vessel can be loaded with ten or twelve thousand tons in less than an hour, but usually two or three hours are consumed.

The capacity of the principal ore docks in this harbor is shown by the following table:

Road.	Location.	Storage capacity.
		Long tons
Duluth, Missabe & Northern	Duluth	38,400
Duluth, Missabe & Northern	Duluth	57,600
Duluth, Missabe & Northern	Duluth	76,800
Great Northern	Superior	112,200
Great Northern	Superior	105,000
Great Northern	Superior	97,800
Great Northern	Superior	90,600
Northern Pacific	Superior	35,700
Soo R. R.	Superior	90,000
Total		704,100

In addition to the above the Duluth, Missabe & Northern Railroad is building a new concrete-steel dock which will have a capacity of 120,000 tons and, when completed, will be the largest and most up-to-date dock in the world.

The ore docks also have a rail capacity for receiving daily upwards of 7,000 cars and shipped, for the year 1912, 24,506,214 long tons.

COAL DOCKS.

Duluth-Superior has twenty-three coal docks, which will receive by vessel from Lake Erie ports during 1913 more than 9,000,000 tons. Many of these docks are of large size, one covering an area of 40 acres. The more modern of the docks are equipped with the latest appliances for handling this commodity with machinery developed to a high degree of efficiency for unloading vessels and for piling the coal. The bridge system and the cable system are used, with electricity as the power in many cases. There are usually three or four hoists to a dock, having grab buckets of from 2 to 6 tons capacity. Each hoist will handle two or three hundred tons per hour. A day or longer is required to unload a large vessel.

In addition to the coal docks already built there are three new concerns building additional dock space. The new wharf of the Pittsburgh Coal Company will have an area of over 70 acres and will probably be the largest in the world. The total capacity of all at present is 8,505,000 tons, and those building will give 1,500,000 tons additional capacity.

Coal is shipped to interior points by rail, and usually in box cars which bring grain to this port from the interior. From 25 to 40 tons are loaded into each car. These cars have side doors, and the spreading of the coal over the floor of the car is accomplished at some of the docks by a special machine, called the Ottumwa loader. Another device is called the Smith cradle loader. By this device the car is tilted to an angle of about 45 degrees, first in one direction and then in the other, to allow the coal to run over the entire floor of the car; it is operated by one man and will load from fifty to one hundred cars in a day. The usual rate is six cars an hour, although a single car may be loaded in six minutes. Labor-saving machinery reduces the cost of handling coal to a low figure and lessens the delays and losses to the company in case of labor strikes.

GRAIN ELEVATORS.

The loading of grain into vessels is by gravity and is quickly done. Boats have entered the Duluth Canal and cleared again after loading grain in a fraction over four hours, which certainly is sufficient evidence of celerity of loading and dispatching vessels. In the elevator are various mechanical appliances for handling the grain: The grain car, which is the ordinary box car, is unloaded by machinery into a bin beneath the car; the grain is elevated by continuous buckets, weighed, cleaned by machinery, transferred to storage bins by belt-conveyors, drawn off by gravity and returned to the shipping house by conveyors, elevated, and loaded into vessels.

The harbor has twenty-three elevators, having a combined storage capacity of 32,425,000 bushels, and during 1912 shipped 110,189,975 bushels of grain.

MISCELLANEOUS FREIGHT.

A large amount of lumber is shipped by vessels and is loaded by hand. Steel rails are transferred from vessels to the dock or placed aboard cars with the aid of a simple steam hoist which forms part of the vessel's equipment. Package freight is mostly handled by longshoremen with hand-trucks; very few special appliances are employed for this kind of freight.

DOCKAGE.

Wharves are free for all vessels to land, but dockage of 40 cents per ton is charged on shipments consigned locally to or from Duluth by lines of railroads not having their own docks. These dockage charges are absorbed by the boat lines.

Each terminal has track connection with one of the railroads. A terminal company built a belt line of track with a view to providing an independent connection between all the lines of road and the terminals; this company was not successful, and later its road was bought by the Northern Pacific Railway Company and its distinctive function was lost.

PRORATING.

Through rates are in effect between points east of Buffalo and west of Duluth by rail, or lake and rail lines; such rates are prorated between the rail and boat lines.

RAILROAD CONTROL.

Eastern roads control all the package-freight boats operating between Duluth and the lower lake ports. The effect of such control has been to advance rates with a view to reducing the difference between all-rail and water transportation and force more of the traffic to the all-rail lines. The lack of modern appliances for the rapid handling of package freight at the terminals has been ascribed to a desire of the roads to avoid cheapening of the water transportation. The effect of this policy has been partially to nullify the natural advantage of the Great Lakes waterway.

Considerable attention should be given to the subject of lack of terminals for package freight, for it looks as if in this failure a greater portion of the advantage of cheap transportation on the Great Lakes has gone to the large corporations. It appears that all rates on bulk freight, such as coal, iron ore, and grain, which furnish the greater portion of freight, have diminished annually, while the rate on package freight which is used directly by the consumer continues to increase. The Federal Government has made the necessary appropriations and improvements, but a great deal yet remains unfinished; and in accordance with the present policy of the Federal Government this is something which legislative bodies

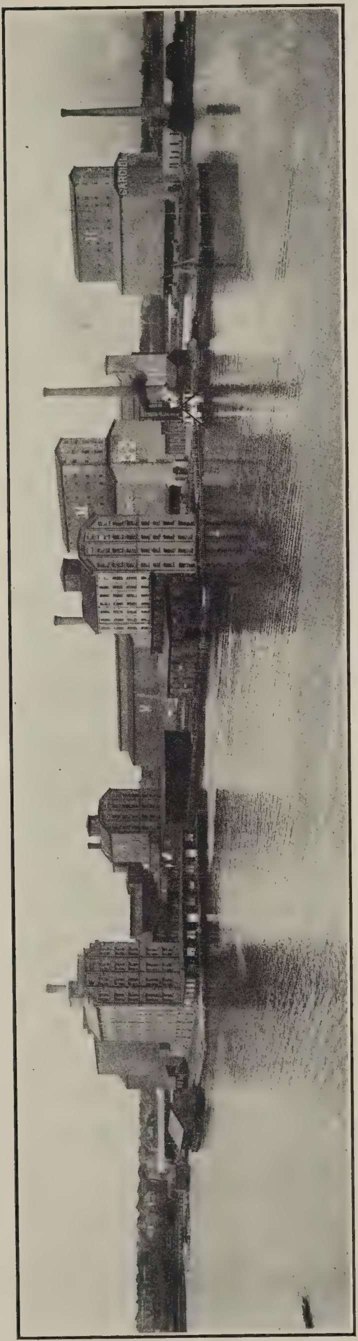


Fig. 5. Grain Elevators on Superior Bay.

should attempt to regulate by enacting suitable and forcible laws, so that the consumer or individual may obtain a direct benefit.

EXISTING PROJECT WITH MODIFICATIONS.

The present project was authorized by the Act of June 3, 1896, "For improving harbor at Duluth, Minn., and Superior, Wis.," and provided for the widening and deepening to a navigable depth of 20 feet of the existing channels, new channels in Allouez Bay and St. Louis River, extensive turning and anchorage basins of a navigable depth of 20 feet at the junction of two or more channels, widening the Duluth Canal, rebuilding the piers at the Duluth Canal and Wisconsin Entrance and finishing them off with a concrete superstructure built of monolithic blocks.

Several changes have been made in the last-named project—that is, by providing an all-concrete construction in the revetment piers at Superior Entry; increasing the depth of the lake approach to the entrances to 30 feet; a radical change in the plans for the improvement of Superior Entry, including breakwaters, dredging, etc.; some additional dredging near a railroad bridge in St. Louis Bay, and enlarging the Duluth Harbor basin.

The existing project, with its modifications, provides for dredging channels to a navigable depth of 20 feet; extensive turning and anchorage basins of a navigable depth of 20 feet at the junctions of two or more channels; the enlargement by about 209 acres of the anchorage area of the Duluth Basin by dredging to a depth of 22 feet; widening the Duluth Canal, rebuilding its piers and finishing them off with a concrete superstructure built of monolithic blocks; excavation of the lake approach to the Duluth Entrance to 30 feet for a width of 300 feet, and for the following work at the Superior Entry: building two concrete revetment piers, one on each side of the entrance, 500 feet apart and terminating near the lake shore of Wisconsin Point; building two converging breakwaters from the shore out to the 30-foot depth, with an opening of 600 feet on line with the axis of the inner entrance, to be of rubble-mound construction, terminating in a crib and concrete pier at outer end and a pile pier at inner end; dredging between the breakwaters to form a channel 600 feet wide and 30 feet deep, and further dredging to form a stilling basin; dredging channel between revetments to a depth of 24 feet; protecting the shore line by riprap, and widening the Superior front channel inside the harbor. Total estimated cost, $6,221,053.

PROJECTS SUGGESTED.

Outer Breakwater.

The construction of a breakwater in the lake to protect the Duluth entrance has been advocated by Duluth citizens, vessel men, and others at various times, with urgency and persistence. In 1870, the year in which the Duluth Canal was started, the question was presented to Congress by a memorial of the Minnesota legislature, urging an appropriation for both the canal and a breakwater.

In 1890, Maj. James B. Quinn, Corps of Engineers, in charge of this district, made a report of a survey and estimate following a preliminary examination for the improvement of the Duluth Canal, recommending the construction of an outer breakwater in connection with the rebuilding of the entrance piers. Major Quinn remarked that he recognized the necessity for some protective construction in advance of the canal entrance, and that he did not think there had been a storm in which it had not been felt by those interested that some such protective covering to the canal was greatly needed.

The breakwater recommended by Major Quinn was a detached one, 2,220 feet long, located 3,330 feet in front of the entrance and placed at right angles to the axis of the canal. It consisted of timber cribs upon a rock embankment and surmounted by a concrete superstructure. This project does not appear to have met with favor. The plan seems objectionable on account of its serious obstruction to vessels entering the harbor. It is too near the entrance and, being directly across the course of vessels, makes the turn to pass around it difficult and dangerous in times of the severest storms, when a breakwater would be most needed.

A Board of Engineers in 1906 met to consider further modifications in the existing plan of improvement and took up, among other subjects, the question of a breakwater at the Duluth entrance. Much interest in this matter had been aroused among the citizens by reason of the terrible storm which had occurred the previous year, in which the steamer *Mataafa* was wrecked and nine lives lost. In attempting to enter the harbor, another steamer was damaged by striking one of the piers and sank in the harbor; further damage was caused to wharves by waves entering through the canal.

For reasons stated in their report, but mainly on account of the cost, the Board reported adversely on a breakwater.

Another Board of Engineers in 1907 made further examination of the project for a breakwater at the Duluth entrance, together with several other questions. At a public hearing, an outer breakwater was strongly urged by a majority of the speakers and communications received. They advocated the construction of a breakwater practically parallel to Minnesota Point and about 1½ miles from the end of the canal piers, and running out from shore for about 1½ miles to a point somewhat beyond the intersection with a line in prolongation of the Duluth Canal. In the opinion of its advocates, this breakwater would protect the Duluth Harbor basin from wave action, would give a safe entrance through the Duluth Canal, and would provide a protected outer harbor of refuge for boats which for any reason could not enter the inner harbor.

The Board concluded that at present such construction was inadvisable for two reasons: The proposed improvements at the Superior Entry would be available for all vessels, which would render the Duluth breakwater unnecessary for a safe entrance, and the protection it would afford to wharves within the harbor would not warrant the great cost, which was estimated to be between four and five million dollars.

Little has been said about a Duluth breakwater since the meeting of the last-named Board. In view of the possibility of the subject being revived at some future time and for the purpose of lessening the cost of such a structure, an embankment of waste sand from dredgings of the harbor basin has been dumped without extra expense along a line approximately 1½ miles from the Canal and which has been considered a good location for a breakwater in case one should at any time be built. There has now been dumped along this line nearly 4,000,000 yards of dredged material and it has formed an embankment 6,600 feet long, with the crest up to within 43 to 45 feet of the water's surface where the original depth was mostly between 60 and 72 feet. The dumping was done entirely along the center line, but the sand in falling through that depth of water spread out to a width of 600 feet or more. The side slopes on the steepest portion of the cross section average 1 on 9 on the seaward side and 1 on 10 on the harbor side, and retains its form with but little apparent change. In case a breakwater should be built along this line, the sand embankment would probably reduce the cost about one-half and would materially change the conditions entering into the question.

Another possible condition is that the city would some time be willing to cooperate with the Government in the construction of a breakwater running out from the north shore, on account of the protection it would afford to the shore property, and also enclose an area available for park purposes.

It would appear that since Superior Entry is so amply protected with converging breakwaters that no further steps need be taken to improve the Duluth Entrance for many years to come, if ever. The days when ships can not enter the canal or even enter without great risk are very few and then they may always change their course and enter by Superior Entry. The great cost involved in protecting the Duluth Canal with an outer breakwater would always be out of reason when comparing it to the benefits to commerce, as this would mean a saving of only a half hour in the running time for a few boats which attempt to enter the Duluth Canal in a severe storm and are compelled to go to the other entrance.

Converging Breakwaters.

For an entrance situated on a continuous shore line, the converging type of breakwater is a good one and has been adopted for a number of harbors on Lake Erie, as at Lorain, Conneaut, Ashtabula, and at a few harbors on Lake Michigan, Ludington and Manitowoc. On Lake Superior there are two examples, that at the upper entrance to the Keweenaw Waterway and the uncompleted one at Superior Entry.

In this type there two breakwaters with an opening between them usually 400 to 600 feet wide, this opening being placed on line with the axis of the entrance channel and at a distance of from one to two thousand feet therefrom. The two breakwaters extend shoreward, diverging with an angle between them of between 60 and 90 degrees and thus form a stilling basin within which the waves entering through the opening spread out and reduce in height and so make the entrance to the inner channel more easy and safe.

The amount of reduction effected by the stilling basin in the height of waves has been investigated by Thomas Stevenson and expressed by a rather complicated formula, which is given in his treatise on harbors and has been freely quoted in other publications. It depends upon the width of the outer opening, the width of the basin at the inner entrance, and upon the distance from the outer to the inner entrance. At the breakwaters at Portage Lake Canal (Keweenaw Waterway, Mich.) the computed reduction makes the height of a wave at the inner entrance 0.23 of the original height, and this agrees fairly well with the observed reduction as found by observation. At the Superior Entry the computed height of waves at the inner channel is 0.29, expressed as a fraction of the height of waves in the lake.

There are several points in favor of the converging type of breakwater. The vessel may run a straight course into the harbor through the two openings if the waters are not too rough, and even if rough, provided it is running ''before the wind.'' If there is a cross wind and sea, it may even then run into the outer entrance before the wind, or with the wind over the stern quarter by taking a diagonal course into the stilling basin and then when in the basin straighten up for entering the channel.

Entrance into the harbor is in two stages: First, through the outer and wider opening where the sea is roughest, and next through the inner and narrower opening where the sea is smoother.

At the Duluth Canal, local conditions are favorable for an outer breakwater by reason of the proximity of the north shore. This permits the building of a breakwater out from the shore at any desired distance beyond the entrance, shuts off all sea from the north, and if the breakwater is far enough away it allows the vessel to pass around the south end without danger of either striking the breakwater or going ashore. The location referred to in the 1907 Board report extends from shore a distance of 1½ miles, taking it well past the front of the entrance, so that waves passing around the south end would be greatly reduced before reaching the Duluth Canal. The south end of the breakwater also is at a distance of 1 mile from the shoal water of Minnesota Point, which should give a vessel of any size ample room to make the turn to get behind the breakwater in the severest storm without danger of being thrown on the beach. It would give more room and greater safety than if entering between converging breakwaters with an opening of 600 feet.

Central Canal.

A single entrance to this harbor by an opening through Minnesota Point near its center, or at a point directly opposite Connors Point, and the closing of the present two entrances has been advocated at various times. During the nineties the citizens of West Superior were particularly active in its recommendation, as was also West Duluth. Duluth and East Superior people were opposed, the opinions of each locality being largely based on local interests. People of Duluth, though favoring the two-entrance plan, have a grievance towards it, due to the fact that the wharves in the Duluth Harbor Basin at the Duluth Canal are somewhat exposed to wave action. Those interested in dock property or business have from time to time suffered losses which have amounted to, probably, $50,000 or $100,000, though the annual loss is not more than one-tenth part of the above figures. In addition to this loss there is also an occasional delay to vessels, due to inability to get alongside of wharves during a heavy northeast gale.

The reason for the damage by wave action is due to the fact that the waves on entering are prevented from spreading toward the northwest, due to the proximity of the wharves. These wave disturbances are not felt at the docks near Superior Entry, due to the breakwater outside the entrance piers forming the stilling basin, which reduces the waves on entering between the piers and the greater distance to the wharves in the harbor itself.

If this harbor were to be improved *de novo,* this plan would have several strong points in its favor, such as simplicity, economy, and permitting the development of the entire length of Minnesota Point for commercial purposes by the access of railroads and highways without bridging or tunneling.

On the other hand, the plan of two entrances has its advantages. It gives vessels arriving at or departing from this harbor more direct access to the wharves. It is estimated by an analysis of the actual business transacted at the various wharves that the number of ton miles for the freight carried is materially less than it would be for a central canal. With the two entrances and the currents ebbing and flowing almost constantly through them, there must be less ice formation at the extreme portions of Superior Bay, a later freezing up and an earlier opening than with a central canal. This makes a longer working season and there is also less stagnation and pollution of the water, which has some importance from a sanitary standpoint. Again, there is less danger of blocking up the harbor by the sinking of a vessel across the entrance, for if one should be so closed the other would be available, while with a single opening such an obstruction might completely bottle up the port.

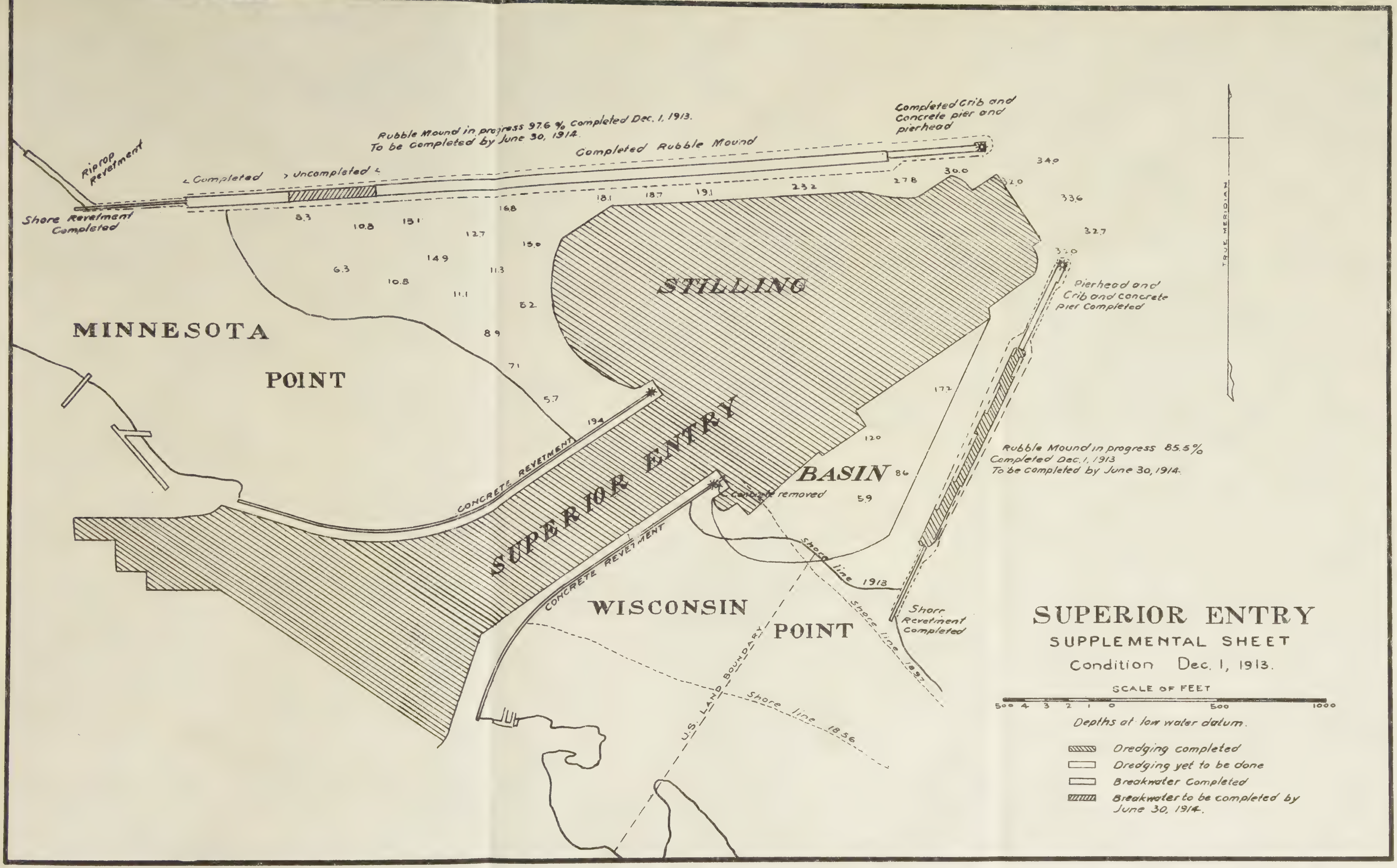
The question of ice interfering in the spring with two entrances is much less important, because, as a rule, one is much more open than the other, the wind having a different effect at the two points. The spring of 1913 found the Duluth Canal easy for entrance and departure, while the Superior Entry had fields of ice approximately 2 to 4 miles in breadth at all times until June 1.

Finally, there should be a very great advantage in favor of a central canal to justify throwing away the three million dollars or more which have been already expended in the existing improvements at the two entrances.

RESULTS ACCOMPLISHED.

The work planned under the existing project as already described is now well advanced toward completion. A few of the more important items of work accomplished are described herein and are shown on the two maps accompanying. There are 17 linear miles of dredged channels and 360 acres of anchorage and turning basins, with a depth of about 22 feet to give a navigable depth of 20 feet at mean low water.

New piers for the Duluth Canal have been built with substructures of very strongly built timber cribs founded on bearing piles with a protection of heavy steel plate, and surmounted with concrete superstructures which constitute a promenade. These cribs, notwithstanding their good design and extraordinary strength, have shown an undesirable elasticity, due to varying heads of water caused by waves during severe storms. While no serious damage has occurred to the concrete superstructure on this account, still the result of this small movement is evident, through slight spalling at the block divisions of the monolithic concrete superstructure as well as in the footing blocks upon which the large monoliths are superimposed. This movement has been retrogressive in its action, no doubt due to the compression of fiber in the timber and the greater solidity of the resulting structure. This introduces the question of the desirability of superposing an elastic substructure with a rigid superstructure where similar or worse conditions of wave action exist. It is believed that in cases where the stone-filled timber cribs are deemed a necessity that the cribs should be built to a desired elevation, the use of the footing blocks omitted, and all monoliths which span a crib joint should be heavily reinforced with steel to provide against damage by either vertical or horizontal movements. An expansion joint should be provided between the monoliths by the introduction of ¼-inch plaster-board or some similar substance.



SUPERIOR ENTRY

SUPPLEMENTAL SHEET

Condition Dec. 1, 1913.

Rubble Mound in progress 97.6 % completed Dec. 1, 1913.
To be completed by June 30, 1914.
Completed Crib and Concrete pier and pierhead
Completed Rubble Mound
Riprap Revetment
< Completed
> Uncompleted <
Shore Revetment Completed
34.9
30.0
27.8
32.0
33.6
32.7
32.0
23.2
19.1
18.7
18.1
16.8
8.3
10.8
15.1
12.7
15.0
14.9
11.3
6.3
10.8
11.1
8.2
8.9
7.1
5.7
19.4
STILLING
BASIN
MINNESOTA
POINT
SUPERIOR ENTRY
CONCRETE REVETMENT
CONCRETE REVETMENT
Concrete removed
Pierhead and Crib and concrete pier Completed
17.2
12.0
8.6
5.9
Rubble Mound in progress 85.5% Completed Dec. 1, 1913
To be completed by June 30, 1914.
Shore line 1913
Shore line 1892
Shore line 1856
Shore Revetment Completed
WISCONSIN
POINT
U.S. LAND BOUNDARY
TRUE MERIDIAN
SCALE OF FEET
500 4 3 2 1 0 500 1000
Depths at low water datum.
▨ Dredging completed
☐ Dredging yet to be done
☐ Breakwater Completed
▨ Breakwater to be completed by June 30, 1914.

By this change in construction the necessity for the footing blocks would be obviated, as it allows the base of the monolith to be built under ordinary good weather conditions and the weak point of footing blocks, due to the multiplication of construction units and vertical planes of weakness, would be eliminated. The difference in the excess cost of concrete in footing blocks set in place and that of the ordinary monolithic work would be saved and the reduction of building units effected.

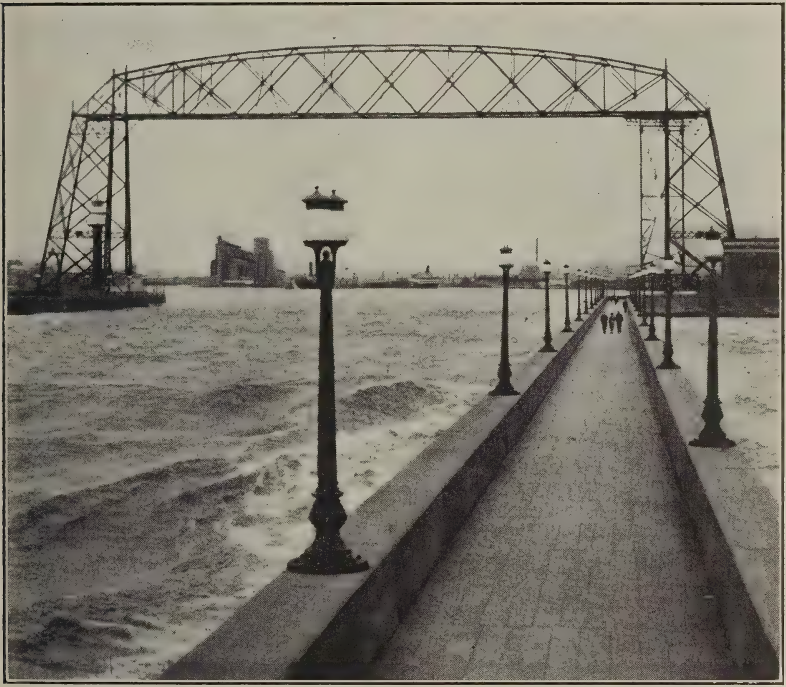


Fig. 6. Duluth Canal Piers. Viewed from north pier, looking toward Harbor basin.

At the Superior Entry the extensive work of reconstruction of piers on a new plan of all-concrete section, the building of converging breakwaters, the deepening of the inclosed stilling basin and of the entrance channel and the enlargement of the inner channel has been in progress for the last ten years and is expected to be completed in 1914. In this construction, footing blocks were set at elevation 1 foot above datum on crib substructures of the breakwater heads and surmounted with heavy concrete monoliths. The cost of the concrete in place on the breakwater heads was $7.85 per cubic yard for footing blocks and $5.39 for monoliths. At Superior Entry, with a view to preventing, as far as possible, any vertical movement in the ribs due to wave oscillations, 12 by 12 inch timber was used in the rib bottoms instead of 6 by 12 inch, as at Duluth; all blocks spanning crib joints were amply reinforced with steel, and plaster-board ¼-inch thick was used for forming the expansion joints between the monoliths. The axis of the north breakwater at Superior Entry lies at an angle of 45 degrees to the path of waves in northeast storms, which would reduce to one-half the normal force of wave at right angles to the axis of the breakwater. Before the completion of this superstructure a slight movement of these cribs was apparent, but after the superstructure was completed, reinforced as described, no movement has been observed.

With a view to minimizing vibration and movements in structures exposed to wave action and also securing greater rigidity and permanence, a design for all-concrete canal revetments or piers for the ship canal entrance to the harbor at Superior Entry, Wis., was adopted and the revetments, aggregating 3,680 feet in length, built accordingly. For a full description of these revetments and their construction as far as completed in 1904, see Report of Chief of Engineers, 1904, Appendix AAA, technical details, pages 3779 to 3803. These revetments were built in water from 21 to 23 feet in depth, and 1,520 feet of the north all-concrete revetment was built in Lake Superior, subject to all the variable conditions of that lake without serious interference or loss, which proved for this case that this class of work is practicable for exposed lake locations. The relative cost of this work, compared with timber cribs filled with stone, has been discussed very thoroughly in Transactions of the American Society of Civil Engineers' International Engineering Congress, 1904, pages 290-292; *Ibid,* pages 361-368. No vibration or visible movement other than that due to thermal causes has been discovered in the all-concrete piers, and from their close approach in cost to timber and stone construction, as evidenced by the discussions referred to above, as well as stability and freedom from undue vibration when exposed to wave action, the extremely permanent character of their monolithic construction and as reducing upkeep to a minimum and, finally, the facility with which they may be constructed, warrants a careful consideration of their possible adoption in all large works.

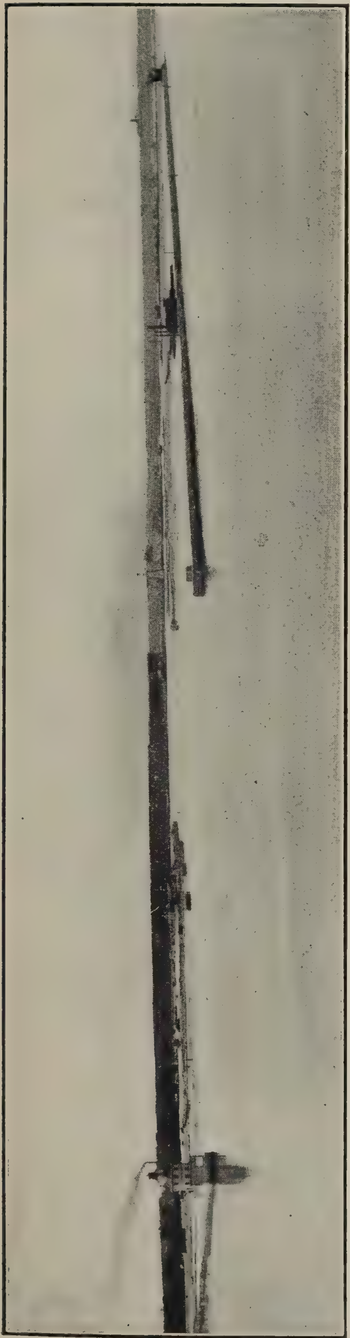


Fig. 7. Superior Entry. Showing outer entrance, breakwaters, stilling basin, revetments of canal and harbor basin in rear. Viewed from lake.

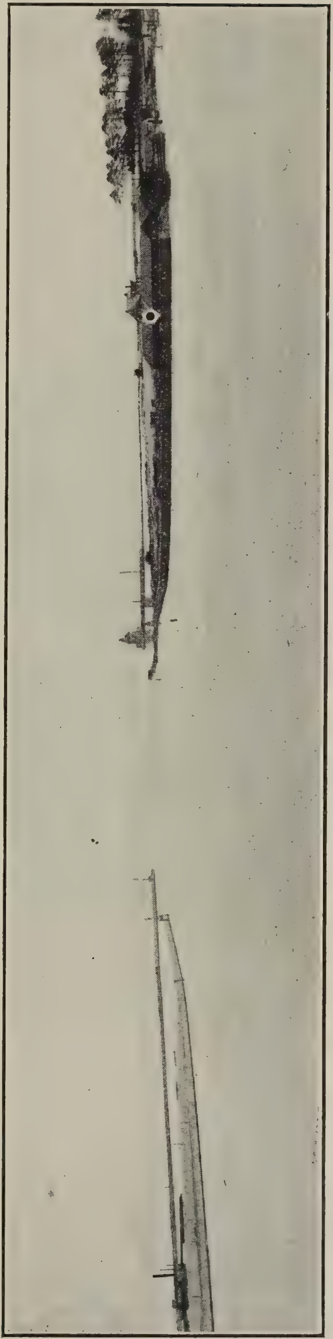


Fig. 8. Superior Entry. Canal in foreground, stilling basin, breakwaters and lake beyond. Viewed from harbor basin.

The two converging breakwaters at Superior Entry have been completed as to the breakwater heads of stone-filled timber cribs with massive concrete superstructure, all on pile foundation and heavily riprapped, aggregating 900 feet in length, also completed as to the concrete shore revetments founded on stone-filled pile foundation aggregating 896 feet in length. The rubble-mound portion of these breakwaters is now under construction and estimated as 92 per cent complete. The rubble-mound construction has been mainly done under contracts, the money being provided for by appropriations under the River and Harbor Acts on estimates made for each year. A part of the work, amounting to 24.7 per cent of all the work done, has been performed with United States plant and hired labor. Under contracts, a total of 258,345.50 tons have been placed at a contract price of from $1.50 to $1.65 per ton of 2,000 pounds.

With United States plant a total of 49,333.72 tons of purchased rock has been placed at a cost not exceeding $1.25 per ton, and 35,698 tons of rock from and around old piers in process of removal at a cost slightly over 30 cents per ton.

For the dredging at Superior Entry, contractors' bids have presented a wide variation, ranging from 50 to 8 cents per cubic yard. The excessive prices prevailing with the dredging companies during the early period of the work necessitated the building of a small 15-inch hydraulic dredge by the United States. This dredge has been in constant use every working season since its construction and has handled upwards of 1,000,000 cubic yards at costs varying from 4 to 13 cents per cubic yard, but it is believed that its greatest value has been in causing a very noticeable decline in the prices bid by contractors for dredging in this harbor.

In the plan for dredging, there remains about a million yards to be excavated in the extension of the Duluth anchorage basin, and this also will be finished in 1914. The above-named items will mark the completion of the present project.

PROSPECTIVE IMPROVEMENTS.

Dredging.

Several extensions of dredged channels and basins seem likely to be required at some time in the future, in order to keep pace with private improvements in this harbor. One is the enlargement of the Superior Basin to provide for the anchorage of vessels and a wider entrance to the canal from the Allouez Bay channel; this would embrace the removal of the shoal, which at present exists along the harbor end of the south concrete revetment. This revetment has a depth of only 12 feet for 282 feet at its harbor end, and was so designed with a view to economy in concrete. The necessary work, however, required on special forms for this reduction in depth rendered this design one of very doubtful economy.

There is litle doubt but that the canal entrance should be dredged to its full depth close up to the south revetment in the near future. Before this is done, the portion of pier only 12 feet deep should be made secure by a concrete revetment built along the subaqueous blocks for the entire length of the shoal portion and extending well below the depth intended to be dredged.

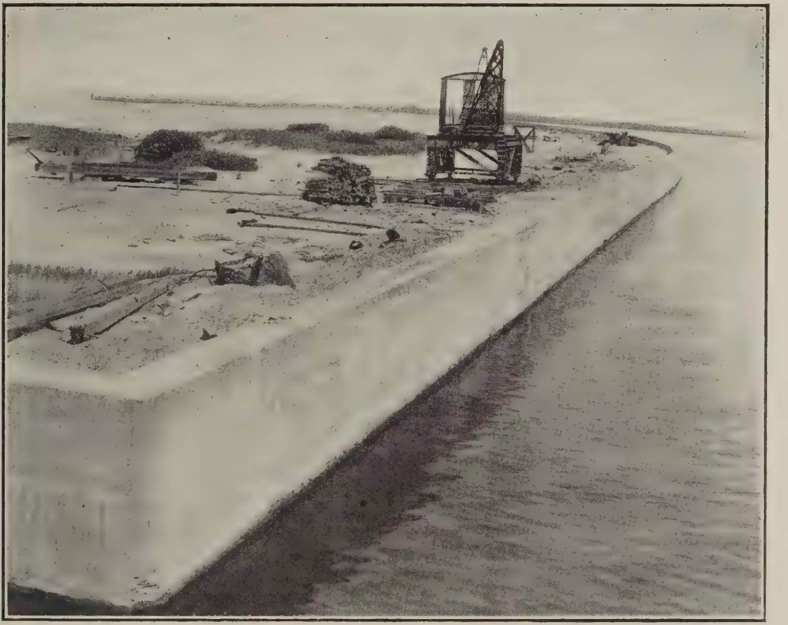


Fig. 9. Superior Entry. Inner end north concrete canal revetment.

Further dredging in Allouez Bay was adversely reported upon only a few years ago, and is not now urgently needed, but may be before many years. Another possible extension is in the Allouez Bay channel, where indications are that additional wharves will be built. Material from these extensions not needed for dock filling might well be towed at small extra cost into the lake and dumped inshore in front of the Barrons of Minnesota Point, where severe storms have broken through at times, and thus widen and strengthen this weak place in the natural breakwater of this harbor. Extension of the deep-water channel up the St. Louis River to New Duluth or farther and, at the same time, the extension of harbor lines on both sides of the river, may be required in case the hoped-for industries become established up the river as a consquence of the completion of the new steel plant now in course of construction. Minnesota Point on Superior Bay, which is now isolated by the two entrance channels, may some time be opened up to business by railroads connecting either by a bridge across St. Louis Bay or tunnels under the entrance channels. In such event there would arise the necessity of a dredged channel along the Minnesota Point harbor line, which has already been established.

The present docks and wharves are fairly well scattered and separated by numerous large unimproved tracts of frontage, which should be developed before any new portions are added. In looking at the growth of the city of Superior, a person is surprised at the many natural advantages which the city possesses. On the other hand, Duluth was not so fortunate. Of Superior it may be said that she has been cursed by these natural advantages, for she has grown and spread out of all proportion to her population and nothing is finished, and she has become an overgrown village. In considering any extension or enlargement of the Duluth-Superior Harbor, one should be governed to some extent at least by this lesson and not extend and enlarge until all the present available portions are used to good advantage. Real estate men and boomers of one kind and another will always cry for an increase and betterment, but it would seem that Duluth-Superior has now so much that is developed and has made her great, and even so much more that may be developed, that she should not want much more of an increase in deep-water channels and basins until the necessity actually arises.

Bridges.

With the growth of the cities located on this harbor there will probably come the need of additional bridges across the navigable channels, in order to accommodate the railway and highway traffic. A highway bridge across the river between West Duluth and Superior has already been under consideration and other bridges are likely to be required farther up the St. Louis River, following commercial and municipal developments which it is believed will receive an impetus from the steel corporation's new plant. No further bridging of St. Louis Bay is likely to be needed, but there may be

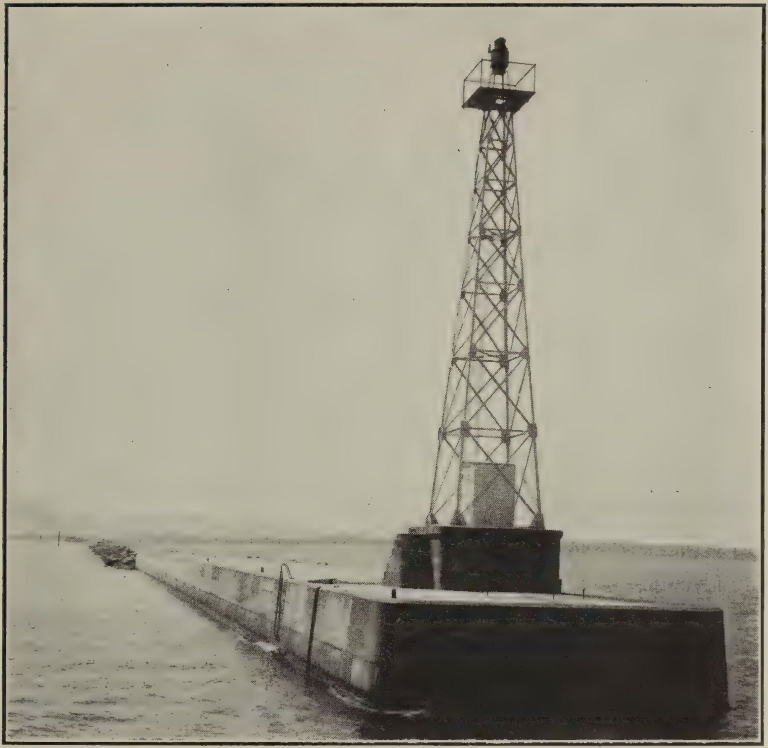


Fig. 10. Superior Entry. North breakwater with concrete pier-head as viewed from lake.

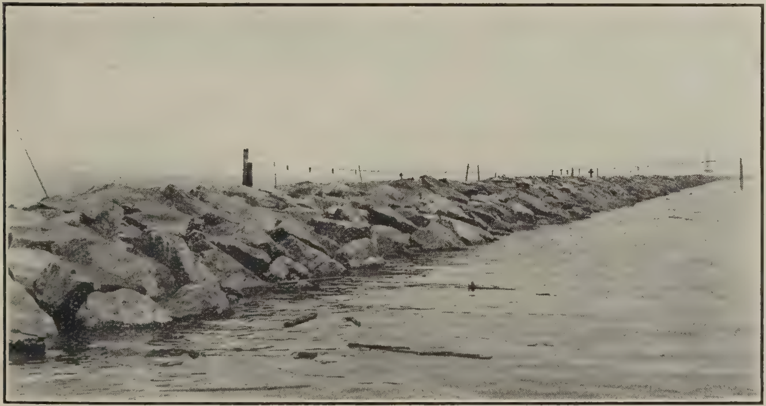


Fig. 11. Superior Entry. North breakwater. Looking toward lake.

one or more bridges projected across Superior Bay to reach Minnesota Point if a tunnel is not constructed.

A bridge crosses the Duluth Canal, but the same can be used only by pedestrians and wagons. It is known as the ''Aerial Bridge,'' and consists of a tower on each side of the canal connected with a truss, the bottom chord being 135 feet above the water. The bridge itself is a suspended car, attached to a truck which rolls on a track at the bottom of the truss and carries this car 14 feet above the water. When the question of bridging the canal was first mentioned, it was fought and opposed by all the marine people, due to the dangers which would be bound to exist in a structure which had to be turned or lifted out of the way. On account of its position and the severe storms, it might mean the wrecking of a ship if it had to check its speed in the canal during bad weather should an ordinary bridge fail to open promptly. This type of bridge answers the needs of the marine man, for it leaves an unobstructed channel at all times save when the car is rolling across which takes only a few moments. It is a bridge which is always open save for the occasional passages of the car.

EFFECT OF WATER TRANSPORTATION ON RAILROAD RATES.

For a comparison between the cost of improvements and the value of commerce, it may be stated that the total amount of money expended by the Government on the improvement of this harbor from the commencement of work in 1867 up to June 30, 1913, is $7,121,175.42. The vessel freight received and shipped at this port during the same period was 407,340,635 short tons, and its market value was $4,206,316,156. From this, it appears that the cost of Government improvements has been about one-sixth of 1 per cent of the value of the freight transported.

The annual cost of maintenance of Government operations at this harbor, consisting of repairs, removal of shoals, and administration, is approximately $14,262.27. This amounts to $0.0003 per ton of vessel freight for the year 1912 and to 0.04 per cent of the value of this freight.

Effect of project on freight rates: It may not be possible to give exact figures showing the effect of the improvements of this harbor on freight rates, but the following statements have a bearing on the questions:

The average rate on freight passing through St. Marys Falls Canals in 1912 was 0.67 (two-thirds) of 1 mill per mile per ton, and the average haul was 831 miles. If the same freight had been carried by rail the rate would probably have been as much as 3

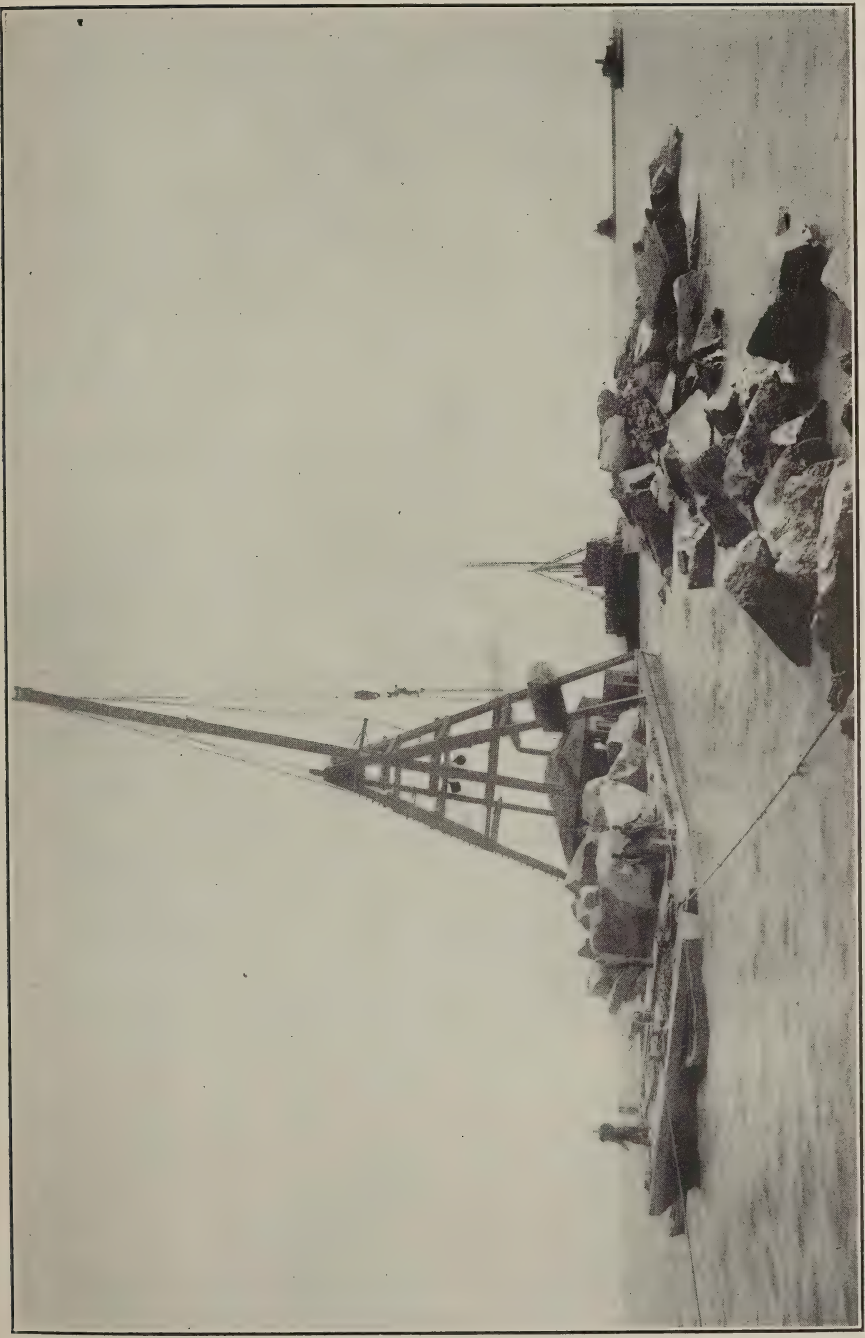


Fig. 12. Superior Entry. North breakwater under construction. Stone weighing 10 to more than 23 tons.

mills per ton mile, making a difference of 2.33 mills per ton mile. Assuming this difference to apply to freight for Duluth-Superior Harbor, and that the average haul is 831 miles, the saving in cost of transportation by water would be $1.94 per ton, and for the 41,474,776 tons received and shipped at this harbor in 1912, the saving in costs amounts to about $80,461,065 for that one year.

CONCLUSIONS.

That upon completion of the present project there should be no need of further improvement, except maintenance, for some years to come.

That if any improvement is made in the near future it should be in the vicinity of Allouez Bay.

Any plan involving the construction of a breakwater in front of Duluth Canal will not be a necessity when the Superior Entry is completed in 1914.

In designs for wave-resisting structures, where it is proposed to superpose a stone-filled timber substructure with a concrete superstructure, great care should be exercised in locking the cribs of the substructure securely together by means of horns filled to enter vertical grooves in the opposing crib; that the use of the smaller concrete footing blocks under the larger monoliths should be abandoned; that where a monolith spans a vertical crib-joint very thorough steel reinforcement should be provided and that expansion joints of not less than ¼ inch should be made between the monoliths.

That well-designed structures, built entirely of concrete, whether intended as piers, sea walls, or breakwaters, are admissible, desirable, and economical on the Great Lakes where the magnitude of the proposed work and estimated cost is such as to admit of the installation of proper plant for carrying it to completion without a cost out of proportion to the amount involved in construction.

For the class and extent of rubble-mound construction as shown at Superior Entry, it is believed that the work could have been performed much more economically with United States plant and hired labor and that an economy of not less than 25 cents per ton could have been effected by this method. It is further concluded that if it was considered expedient and economical to perform this work by contract, that the very considerable outlay and expense involved in the preparation of proper plant for executing the contract would have demanded the continuous-contract plan to justify the contractor in making proper preparation for doing the work.

From what has been stated with regard to prices for dredging, and especially at Superior Entry, Wis., and the effect of Government ownership of a dredge at that place, it is concluded that it would be very economical for the United States to own and maintain a first-class dipper-dredge in the Duluth district. There will always be a considerable annual amount of work in maintenance and widening of channels and harbor basins, as well as the still more potent reason that the presence of a Government dredge in this district will exert a persuasive influence toward keeping the prices of the dredging companies within reasonable limits.

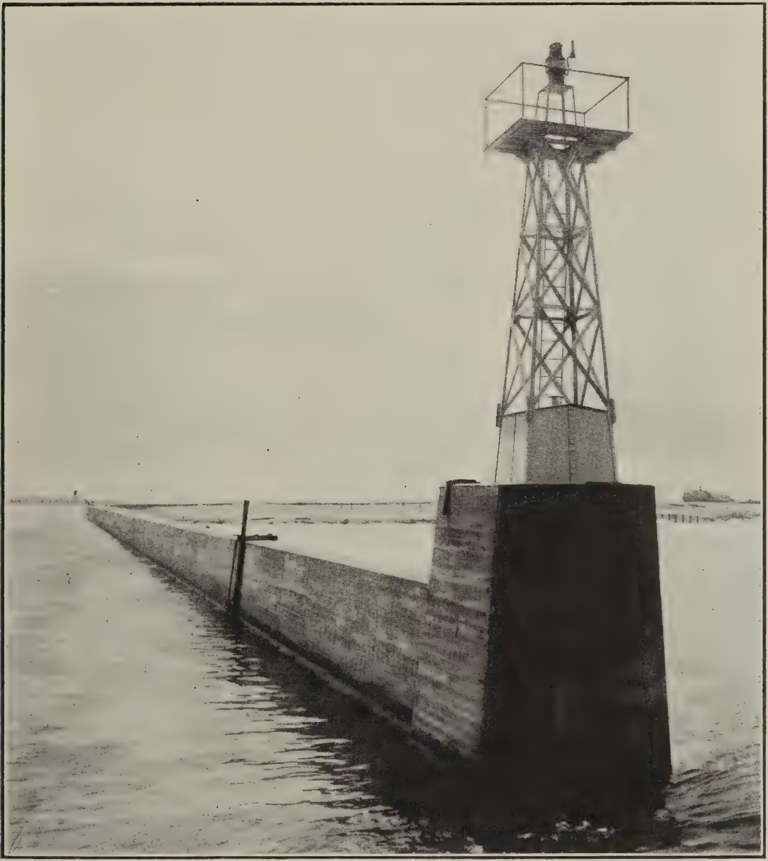


Fig. 13. Superior Entry. Outer end north canal revetment. Viewed from stilling basin.

The Modern Siege

BY

Capt. E. L. DALEY
Corps of Engineers

> "In spite of so much labor and such terrible appliances, modern fortresses are not impregnable."—*Frederick the Great.*

ITS GENERAL PRINCIPLES AND THE IMPORTANCE OF THEIR STUDY.

Frederick the Great's statement of the vincibility of the fortress of his day applies with equal force to the fortress of to-day. Fortresses can be taken, as every recent war has proven. It is a safe prediction, too, that in no extensive war of the future can there be hope of reaching a successful conclusion without the capture of one or more strongly fortified positions.

The discussion of the future struggles between Continental powers inevitably begins with the strategy of fortress warfare and the attack of fortified places. In Europe, military authorities recognize that no small expenditure of time, men, and money must be devoted to the masking, blockading, or siege of fortified positions and regions. The resulting importance which is there attached to this branch of military science is testified to by hundreds of articles in the service papers, and by the extensive and complete regulations for the attack of fortified places which have been adopted by all the great powers, including Great Britain.

The study of siege operations has been comparatively neglected in this country. This has been due in a large measure to our freedom from danger of invasion on either of our land frontiers and the consequent lack of permanent land defenses. In a greater measure it is due to the fact that in changing our Army from the status of a gendarmery with a *posse comitatus* attachment to that of a real military organization, our General Staff, in the few years of its existence, has been so overwhelmed with problems that this particular subject has escaped the attention which its growing importance warrants. Upon the subject of siege warfare, our Army has written little that is authoritative, and yet it is a branch of military science which will be brought home in many of its ramifications, not only to the Engineers but also to the Infantry and the Artillery whenever we engage in another important war. The limits of this paper, as well as the limitations of the writer's incomplete studies, preclude any attempt to state herein authoritative conclusions. However, the writer feels that there is sufficient justification for a paper on this subject, because of the present lack and real need of regulations governing the conduct of siege operations by our Army. These will, in the fundamentals, be in accord with the British, German, French and other foreign regulations, and yet have essential differences because of the lack of similarity in the problems to be solved and the dissimilar character of the recruitment, organization, and training of our Army.

The modern pitched-battle tends more and more to resemble the operations of a regular siege. The weaker side entrenches; the other bombards and attacks, trying to turn a flank or pierce the center. In any case, at some part of its line the offensive will find it advantageous to entrench, sometimes to sap and even to mine. The operations of Grant around Petersburg are a good example of what the offensive of to-day may expect. To entrench the center, without for an instant giving up the offensive against the flanks, while sapping and mining operations are started from offensive trenches to pierce the line if possible, will be as strategically correct in the future as it was at Petersburg and on the Sha-Ho. The inefficiency of his infantry leaders, when the Petersburg mine was exploded, deprived Grant of an early victory in the operations south of Richmond. The ability and versatility of the Japanese infantry, on the other hand, and their willingness to adopt methods analagous to those of the siege resulted in the conquest of the Russian Western Detachment in the battle of the Sha-Ho. In the Russo-Japanese War, sapping and mining were not confined to the operations about Port Arthur, but were employed by both sides in the pitched battles in Manchuria. In his comment on the battle of the Sha-Ho, Lieut. Gen. George Von Caemmerer says, "The Russian Western Detachment was conquered, generally speaking, by the systematic attack with the shovel ——." And, again, speaking of a Japanese advance, "Lastly, they have carried their well-aimed infantry fire so close to the enemy's position with the aid of regularly constructed trenches and approaches in zig-zags as in siege operations that their opponents even under the most perfect cover, have had to acknowledge their superiority of fire.''

The increased efficiency of the modern rifle has greatly increased the tactical difficulties of the attack. The infantry can scarcely hope in the future to take any position well protected by field fortifications without the assistance of the technical troops. As a result, the difficulties, dangers and responsibilities of the Engineers have been enormously enlarged. The sapper, the miner, and the pioneer will find their cooperation needed, not only in the siege proper, but also in the allied and similar operations concerned in the attack of any position well protected by field fortifications. In this connection Colonel Kuhn states, ''I am of the opinion that a defensive position properly prepared and skillfully adapted to the ground will impose upon the attack methods analagous to those employed in sieges, and this without recourse to any very elaborate works of construction.'' Major Woodruff likewise calls our attention to the likelihood of meeting siege conditions in field warfare. He is of the opinion that any field army may be called upon either to attack fortified places or to defend fortified positions, which operations may include all the refinements of a regular siege.

The Engineer, in field operations, must be ready to employ every art and device to prepare for the artillery bombardment and to bring the infantry to a position from which can be delivered the decisive assault. Of this cooperation which must exist between the Artillery, the Infantry, and the Engineers, General Von Berhardi, in the description of an attack against a position protected by field fortifications, says, ''Covered by this fire, the infantry, accompanied by numerous parties of sappers, must work up to the enemy's position without a break——.'' Examples of this cooperation can be found in the operations around Liao-Yang and on the Sha-Ho.

The successful commander of the future will be the one who will bring about the proper coordination of these three arms: Artillery, Infantry, and Engineers. He must also have the versatility to recognize the moment when the advantages of open operations at any point of the line are outweighed by the slower, less appealing, but surer sap. It will, in the future as in the past, take greater strength of character and greater resolution to seize the pscychological moment for adopting the wearisome toil with the spade than to order the glorious, but vain, foolish, and costly assault.

Until a dozen years ago, the very prevalent idea as to the defence of our coast frontier was that it was a purely material affair of battleship armament versus concrete and earth on the one hand and land guns versus ship armor on the other. The subject of coast defence has, however, of late received much broader treatment. So much so,that coast defence is now admitted to be much more than a problem in mechanics. We have come to appreciate that the elements in the defense of our sea-frontier are not merely mechanical and ballistic, but more largely tactical and strategical.

The elements of the defense of a strategical point on any sea frontier include high-power guns, numerous mortars, a complete system of submarine mines and other obstructions, small caliber guns for mine-field protection and use against torpedo-boat attack, mobile torpedoes, powerful searchlights, adequate power plants, light-draught coast-defence vessels, and fortifications for land defence. Of these ten elements, all are now in a high state of development and undergoing constant improvement with the exception of the land defences. Yet, if we are to believe the lessons of history, the brunt of the defense of a strategic harbor will fall on its land defences. It was so at Cartagena, Louisburg, at Charleston, at Vera Cruz, at Mobile and at Santiago. Sevastopol proved this, Wei-hai-wei was no exception and Port Arthur confirmed it.

The methods of the attack always conform to the weaknesses of the defense. It is admitted that the expensive battleship fleet is no match for the modern seacoast fort. The front doors to our harbors are therefore firmly and securely bolted and barred, but the back gate gapes open with scarcely anything more forbidding than a ''Keep Off the Grass'' sign to protest the entrance of an hostile army. It may be laid down as an axiom that with the control of the sea in other hands than our own, we can not prevent the landing of an invading army on our shores. Our entire fleet concentrated in the Atlantic is not invincible, and at the present we have a negligible force to protest the mastery of the Pacific. Therefore the possibility of a turn in world politics that would bring on a clash between the United States and a world power carries with it the probability of an hostile invasion. The first objective of such an invading army will be the capture of a harbor of the first class to complete its line of communications. Its triumphant fleet will blockade the harbor from the sea, while the land forces move the wide open door of our coast defences.

If the Engineers in charge of the land defences are energetic, full of resource, and fortunate in carrying out the land defense projects which have been drawn up in peace time, we can stave off even a first-class power for a time. But, if we are to gain for the militia and volunteers the time so necessary for their training after our coast is in a state of siege, we must now appreciate the importance of the problems which we will then have to solve in any great war. These problems will more nearly approach those of Port Arthur than the defensive situations that arose at Liao-Yang and Mukden.

The land defense of our coast fortifications will doubtless, for financial and political reasons, be of the "put-off-to-the-last-minute" order. All that we can really expect from our present paper-schemes in the early stages of a war is protection against surprise or a sudden raid. As soon, however, as the theater of war has been located and a large city or naval base has become of strategic importance, the main line of land defense must be considerably strengthened. With labor and material abundant, as far as limited time permits, concrete, steel, and other permanent materials should be used. To hope for success in holding any of our important harbors against a determined land attack, no detail of the scheme of defense of each harbor must be left unconsidered in peace time. Not only must there be a general plan for the defense of the harbor, which is known at all times to the defenders thereof, but there must be detailed and specific plans and estimates for each and every construction that is to be attempted. The scheme of defense must be inclusive of every means and every device that will make for a thorough and successful defense. It must be kept up-to-date by being checked annually by the officer who will be entrusted with its execution in war time. There should be no fear of aiming too high or of being too specific in these projects. In the stress of war it will be easier to lop off a well-considered detail than it will be to better a very general plan by hasty improvisation. The attack of Port Arthur and its capture from the land side should bring home to us the vital importance of well-prepared, well-digested and up-to-the-minute schemes for the defense of each of our important harbors.

To those members of the Corps of Engineers who have been engaged during the past half dozen years in working up the details of many of these projects, over ninety per cent of which are now completed, too much praise can not be given for the excellent results that they have turned out. The danger is, that with the completion of the last project and its filing away in some safe devoted to confidential matters, we may consider our work with the land defense of our coasts as an accomplished fact, whereas we will have but completed the initial step. The execution of these schemes of defense under the trying conditions of war will be the duty of the Corps of Engineers. To perform that duty properly, we must familiarize ourselves with the methods of attack which will probably be employed in the modern siege. With all our own preparation, there will still be slight hope of a successful conclusion, unless the Infantry and Artillery can also be brought to a realization of the importance of this branch of military art, for in siege operations of every description the cooperation of the Infantry, Artillery, and Engineers is absolutely essential.

A modern fortress consists of a girdle of detached works of strong profile, surrounding a nucleus of strategical importance at such a distance as to prevent a besieger from mounting guns within feasible range of the place to be defended. The works forming the main defense, usually permanent works protecting the key-points of the line, are connected with one another by discontinuous trenches of the types employed in field fortifications. To further sweep the intervals with efficacious infantry fire, smaller works or groups of trenches of light profile are employed. Although in special cases, heavy guns may be placed within the detached forts, the fortress artillery will usually be placed in batteries in the intervals and slightly behind the main line of defense. The armament will consist of guns, howitzers, and mortars. The concealment of the mortars is their security. The guns depend on armor or thick parapets for their protection, while the howitzers are protected by concealment or armor or both. Free and extensive use is made of obstacles, especially in front of the detached forts and the intermediate redoubts or groups of trenches, in order that these points of support may be capable of a most stubborn defense against any assault. Advanced works will be employed to delay the besieger's arrival at the main line as long as possible. The old enceinte is retained in some cases for sentimental reasons or as a moral support to the civilian population. Some, especially the French Regulations, favor a second line in rear of the main line as a defense against a *coup de main* and as a retrenchment whenever the first line must be abandoned. The main reliance, however, of most modern fortresses will be a single line of detached forts with the heavy artillery in the intervals. These intervals will be protected by the fire of the artillery and by infantry trenches with redoubts or groups of trenches as *points d'appui*

In the above conception of the modern fortress we have not really progressed far from the old enceinte of Vauban. Indeed, the present fortress carries out the analogy of the enceinte with the bastioned trace in so far as its enlarged perimeter permits. The detached forts replace the bastions of the older system. The curtain finds its counterpart in the interval, now protected not only by the cross-fire of the adjacent detached forts but also by small permanent, semi-permanent or temporary works. The ditch of the old order is repeated in the modern fortress, though never continuous. The complicated multiplication of auxiliary works which was a feature of the bastions front, is replaced by a number of advanced works of temporary character and by numerous obstacles. But the germ of Vauban's enceinte remains. The detached fort is a larger and stronger bastion. The interval is wider and a comparatively weaker curtain.

''The purpose of a fortress,'' says von Schwartz, ''is to assist in the stubborn defense of a given point until the end of the war.'' The first step in this stubborn defense will be the location and construction of the main line of detached forts and batteries, the back-bone of the defense. This work will generally be one of the *peace-time* duties of the engineers, though in a country where the doctrine of military preparedness has not been accepted by the political leaders, even a great portion of this construction will be done under the difficulties of war time. The second step in the successful defense will consist in strengthening the intervals so that the attacking force can not break through but must resort to siege methods; and the construction of advanced works to keep the besieger at a distance and delay his arrival at the main works as long as possible. The real measure of success of any siege operations is the length of time that is required to accomplish the purpose of the siege. When the attacker has been forced to adopt the slow, tedious methods of the regular siege, the defense has already accomplished a great deal. The construction of these interval defenses and the advanced works will usually take place in the period from the outbreak of hostilities up to the close attack. The third step in the stubborn defense will always be the real test of the siege engineer. It will consist of all the devices, contrivances and endeavors by which he holds back the inevitable hour when the place must fall, and thus gains time for the field armies of his country or even saves the position until the end of the war or relief comes from the outside.

In any war of the near future, siege operations of our armies would probably be defensive. The character of the defensive measures taken will depend in a great part upon the nature of the attack. As an old wrestling instructor used to caution, ''There's a block for every hold, boys,'' so in the siege, for almost every hold of the attacker the energetic engineer can use the corresponding block. The best preparation for the defense is a thorough knowledge of the methods of the offense.

The capture of a fortress is not an end in itself but a single detail in a strategic whole. The taking of a fortress will scarcely ever be the deciding issue in modern war. The field armies of the enemy are the objectives and their destruction is the ultimate aim of all the operations. However, as every modern army, because of its size will need ample lines of communication, no commander-in-chief can afford to neglect fortified positions or permanent fortresses which can threaten his line of communications. Fortified positions have a temporary strategic value and permanent fortresses have a permanent military value, so that the capture of either will always be of some importance. The commander-in-chief must not, however, permit the minor advantages accruing from their capture to hold back the progress of the main offensive campaign. Considering, then, the military value of the resources of the fortress to his own forces and to the enemy, the danger it threatens to his communications and the importance of its fall to the ultimate aim of the campaign, the supreme commander must decide whether the place is to be masked, invested or attacked.

If the place is of minor importance, a masking force may be desired. This operation, if sufficient for the tactical requirements of the situation, subtracts the fewest numbers from the main army and thus interferes least with the prosecution of the main offensive. The masking of one of our naval bases would be accomplished by a naval blockade.

Investment or blockade will usually be employed when not enough troops are available to prosecute a regular siege, or when time is not an important element. The capitulation of a place can scarcely be hoped for, due to a simple investment, unless the line of investment can be so closely drawn as to cut off the food or water supply of a large city. This last will be possible when the source of water supply is at a great distance from the invested city. Such is the situation of several of our coast metropolises.

The investment of a coast city presupposes the control of the sea and the assistance of the navy.

If the commander-in-chief decides that the strategical requirements demand the attack and capture of the place, three methods are open to him: assault, with or without artillery preparation; an overwhelming bombardment by artillery; the regular siege.

The assault without artillery preparation must be in the nature of a surprise. The chances of its success in these days of telephonic, telegraphic, and wireless communication are very few. Yet the successful torpedo-boat attack made by the Japanese at the opening of the Russo-Japanese War, taken in connection with the known unpreparedness of the Russian garrison in Port Arthur at that time, might lead us to believe that a similar land raid would, at least, have had a temporary success in the capture of the land defenses.

The assault following an artillery preparation and assisted by artillery support, as in field combats, is always the decisive step of a regular siege. But such assaults made against a well-fortified line, when not preceded by the various operations of the regular siege, are, generally speaking, hopeless or excessively costly. Against much inferior numbers, when time is an important element and when a regular siege would be necessarily prosecuted under the disadvantages of an unhealthy climate, there may be occasions when such an assault would be resorted to. The losses though concentrated may be no more, nor as many as the sum total of the daily losses due to the prosecution of a siege under unfavorable climatic conditions. In such assaults, an engineer party should be at the head of each storming column, to clear away obstacles or provide means for crossing them. The assault should be preceded by the most careful and thorough reconnaissance possible. Such assaults, except in the course of the regular siege, will be a rare expedient.

At the end of the Nineteenth Century, a wrong conception of the increased power of modern artillery gave many supporters to that method of attack which depends on an overwhelming bombardment to destroy the defensive ability of a place. Under the leadership of Von Sauer, a number of military men professed the belief that the formal siege was a thing of the past, for the *Attaque brusquée* would entirely replace the old tedious devices of the attack by sap and mine. It was the opinion of the adherents of this principle that the inventions and improvements in war material would revolutionize fortress warfare. They argued that a heavy paralyzing bombardment would entirely destroy the power of resistance of the fortress; and that subsequent operations, such as a series of rushes and lodgments, ending in an assault delivered by great numbers in manner similar to the combat tactics of field warfare would be sufficient to capture a modern fortress. It cost the Japanese 25,000 men to prove the fallacy of this theory against works which were far from possessing the strength of a modern European fortress. They found that the defensive power of fortifications was not destroyed by artillery fire and that bombardment followed by assaults by main force failed. Success was only attained when the Japanese adopted the methods of the regular siege with such modifications and adaptations as were required by the existing conditions.

Modern fortification dates but from 1885. The foundations of the system of the modern siege, however, were laid in 1673, when Vauban first used parallels in the siege of Maestrich. Vauban's practical genius introduced order into the chaos of siege warfare as he found it. He left nothing to chance, but preferred the slow and certain progress of the sap to the losses and setbacks that might follow an unsuccessful assault. His contemporary and nearest rival, Coehorn, the real father of Von Sauer's theory, tried to shorten his sieges by heavy artillery fire and attacks across the open. The superiority of Vauban's method was then apparent and still is. The regular siege of modern times is the siege of Vauban with the minor modifications necessitated by the enlargement of the fortress, its changed character and the improvements that have been made in ordnance.

The method of attack by regular siege makes the shovel the main reliance in the capture of a fortified place. Covered approaches are driven right up to the besieged work with the object of allowing the besieging infantry to deliver the decisive assault at the point and under the circumstances most favorable to itself.

In the discussion that follows of the methods to be employed in a regular siege, the fortress to be attacked will be of the European type where the defence enjoys all the advantages to be obtained by the use of armor and concrete. The difficulties attendant on the defence of works so well prepared might oppress us with the hopelessness of our task when we are called upon to defend a line of earthworks against the regular siege, did we not recall that the places which have longest held out against siege operations, have not been those which depended solely on permanent fortifications built in peace times, but rather those whose stubborn resistance was due to hastily constructed earthworks and improvised defences, built during the progress of the siege to comply with the varying tactical situations that arose. The resourceful and indomitable energy of a Todleben, of a Denfert-Rochereau, an Osman Pasha or a Kondratenko is worth tons of concrete or carloads of armor. In sieges, as in every other branch of warfare, the personal element plays a most important part.

Since the principles that govern the conduct of a regular siege are alike for all countries and all modern times, the sameness in the regulations for the attack and defence of fortified places as issued by the great military powers is not to be wondered at. The differences are only such as could be expected as a result of the varying character of the military spirit to be found in nations.

All regulations insist on simplicity, preparedness, cooperation and sanitation. The keynote of the solution of any siege problem has always been simplicity. Since Vauban pointed out the way at the end of the Seventeenth Century, sieges have been as successful as they have been direct and simple. Those operations which have failed have done so usually because peace-time theories have been allowed to complicate the problem and confuse the real issues of the siege. This simplicity, however, must not be that which results from ignorance and a failure to grasp the situation in its entirety, but it must be the directness and oneness of purpose that results from knowledge well digested; in other words, military preparedness. Outside of the covers of novels, soldiers, unlike poets, are made and not born. The siege engineer is, moreover, self-made. He must in peace-time always bear in mind that the vital irreparable mistake of a day in the future can only be avoided by preparation now. This preparation must also be required of all the personnel and material. In no branch of military art is haphazard and chance more apt to result disastrously.

The third great factor in the solution of a siege problem is the cooperation of the Infantry, Artillery and Engineers. When the Artillery has prepared the way by its fire and the Engineer has brought the attacking forces close to the work by its saps, mines, and demolitions, then and then only can the Infantry deliver the assault with good hopes of success. Sanitation, the fourth element in the siege problem, of great importance in all military operations, often has a decisive influence as to the success or failure of sieges. The most rigid sanitary measures must be enforced. Immediate and severe punishment must be visited on all infractions of the rules laid down by the sanitary inspectors whose duties during the siege will be of the most difficult, exacting and important nature.

A great many diverse elements can affect the result of a siege; the activity of the garrison; the organization of the defense; the relative ability and resourcefulness of the attacking and defending engineers; relative powers of the opposing ordnance; lack or sufficiency of supplies; strategical considerations in the same or a different theater of war; tactical methods and race characteristics of the attacker and defender. Each of the above affects the plans and operations of the attack and defense at some point or other. The measure of success attained will, however, be a direct function of the sufficiency of the sanitary service, simplicity of the scheme of operations, degree of preparedness of the personnel and material, and the extent and character of the cooperation of the Infantry, Artillery, and Engineers.

The regular siege will include all the steps taken by the besieger from the first approach of his troops up to the final capture of the fortress or the abandonment of the siege. But, before there is any movement of troops against the object of attack, even before war has been declared, the Military Information Division of the General Staff will have collected and classified all possible information as to the strength and character of the fortification, the numbers of the garrison, probable armament, stores of provisions and ammunition, water supply, lines of communication, especially railroads, lines of information, resources of the surrounding country, and the political characteristics of the neighboring population. Maps showing topographical features, camp and park sites, and lines of aproach can usually be supplied by the General Staff as soon as the theater of operations is known.

As soon as the commander-in-chief has decided upon operations against a fortress and as a preliminary to the siege proper, a thorough reconnaissance should be made by large bodies of Cavalry, accompanied by General Staff, Artillery, and Engineer officers to obtain the following information:

1. Work necessary to cut lines of communication of the place;
2. Fortifications undergoing construction or new fortifications completed;

3. General dispositions of the defense, especially location of advanced works and outposts;

4. Difficulties to be overcome in bringing up the main body of the besieging force, especially the labor necessary to repair communications. In addition to obtaining this information, the cavalry will endeavor to cut the lines of communication, establish a preliminary investment, make such military demolitions as are possible and prevent the removal of the resources of the surrounding country into the fortress.

The first step in the siege proper will consist in driving back the advanced bodies of the enemy to his advanced works and main line, bringing up the investing force and completing the line of investment. The strength of the investing force depends on the strength of the place and the numbers of the garrison and the number of troops made available by the strategical considerations in other parts of the theater of war. The investment may be most rapidly accomplished by simultaneous movements, but this exposes the various bodies to defeat in detail especially if opposed by an active enemy. It should not be attempted unless cooperation of the various columns is assured. A movement in echelon, followed by a gradual deployment or a deployment to the right and left from a strong central position will be safer though slower methods. The investment will be as close as is possible, though the extended circumference of a modern fortress makes complete isolation impractical. Some parts must be weakly held, others watched by bodies of cavalry or mobile columns of infantry. The approaching columns complete the work of military demolition begun by the advance cavalry. Telephone and telegraph lines are cut. Aqueducts and water mains are shut off. Railroads, canals and other lines of communications not favorable to the attack are destroyed. The countryside is swept clear of provisions and supplies. Everything that can be of use to the besieger is seized. The reconnaissance which was begun by the cavalry is continued by the engineers to determine, if possible:

1. Situation and extent of the enemy's advanced posts and main line.
2. The state of completion of the various works.
3. Enemy's positions, especially of concealed batteries.
4. Location of hostile observatories.
5. Strength of garrison, lines of supplies, etc.

In this reconnaissance, considerable advantage can be gained by the use of aeroplanes, dirigibles, and captive balloons. Besides obtaining the above information, the reconnaissance will determine:

1. Best location for the line of investment.
2. Configuration of the ground between the line of investment and the enemy's works.
3. Facilities for the attack of the besieger or sorties by the defense.
4. Location for besieger's roads, railroads, observatories, etc.

While the forces are being brought up to the line of investment and are engaged against the enemy's outlying detachments and advanced posts, the engineers as well as carrying on the work of reconnaissance, repair and construct roads, railroads and bridges, assist in demolitions and do everything possible to facilitate the advance and union of the infantry columns.

The advanced positions of the besieged, which have been placed out in front of the main lines of the fortress for the sole purpose of delaying the besieger, must be moved against with all energy. If they are unsupported by the fortress artillery, an assault supported by field artillery may be sufficient for their capture. If these measures are not enough, then powerful masses of siege artillery must be concentrated upon them. To defeat the purpose of the defender, which is delay, it must be remembered that time is the all-important element. The advanced works which are close up to the main line of detached forts and thus supported by the fortress artillery may necessitate recourse to the regular formal attack by sap.

As soon as the enemy's advanced troops have been driven in and the general line of investment decided upon from the reconnaissances made above, it will be divided into sectors conforming to the configuration of the ground. To each sector, which is made narrow in order to give depth to the troops placed therein, is assigned a force made up of definite units (army corps, divisions, etc.) and proportioned to the relative importance of the sector in the chain of investment. The commandant of each sector is *alone* responsible for the execution of the mission entrusted to his sector. His instructions come directly from the commander-in-chief. The chief artillery officer and the chief engineer officer of the sector are subordinate to him. Each sector furnishes its own outposts and reserves, ready to get under arms at a minute's notice.

The duties of the outpost are exacting, dangerous and most important, for their positions and early operations, while exposing them to hostile infantry and artillery fire, must form the groundwork for the subsequent stages of the attack. The outposts should be pushed as close to the enemy's advanced works and main lines as is compatible with a suitable defense against sorties of the garrison. Moreover, the outposts should avail themselves of every opportunity of gaining ground to the front. Advances can often be made in the early stages of the siege which can only be accomplished later at the cost of excessive losses. In order to take advantage of all suitable occasions to advance and to give strength sufficient to resist strong sorties of an active enemy, in those sectors in which the investment is to be close, the outpost must be strong, one-fourth of the infantry of the sector with the artillery and engineers necessary for the special situation. Immediate steps are taken by the outposts to strengthen their lines of resistance. and to provide protection against the elements and the hostile artillery. As the attack progresses, the most advanced line of the besieger gradually absorbs the duties of the outposts.

While the investment is being completed, the engineers will superintend the construction of the defenses in their sector, assist in the disposition of the troops, engage in the repair and construction of roads, railroads and bridges, arrange for water supply and disposal of wastes, locate depots and parks, and continue the reconnaissance of the ground in front.

Besides the forces engaged in the work of investment, provision must be made for detaching observing forces to prevent attack from the outside by relieving armies. This duty will ordinarily be entrusted to the cavalry or mixed detachments.

With the completion and organization of the line of investment, we pass to the second phase of the regular siege, which will include all the operations up to the employment of the sap.

The extensive perimeter of the fortress makes an all-round attack prohibitive. Therefore a ''front of attack'' which will be subjected to the most vigorous offensive operations, will be selected by the commander-in-chief after consultation with the chief of artillery, chief engineer and the general staff officers. The aim of all the operations on this ''front of attack'' will be to bring the infantry most easily and most quickly to a point where they can deliver the decisive assault. In reaching his decision as to the front to be selected, the commander-in-chief must always bear in mind that it is only with the preparation, support, and cooperation of the artillery and engineers, that the infantry can hope for a successful issue of the assault. The following considerations will all have weight in governing his choice:

1. General strategical situation.
2. Existing railroad facilities and possibilities for new railroads or lines of communication.
3. Nature of the terrain as affecting the cooperation of the infantry, artillery, and engineers.
4. Location, strength, and armament of the various defensive works, both on the front under consideration and on adjacent fronts.
5. Geological and topographical features which may affect the amount of manual labor in the construction of siege works.
6. Defensive value of sectors against counter-attacks.
7. Possibility of the defense preparing retrenchments on the threatened front.
8. The general purpose of the siege and the direction which would probably ensure easiest and most decisive results.

Although each of the above factors should affect the choice of the ''front of attack'' to a degree, in general, the location of the existing railroads will exercise an almost decisive influence upon the direction to be given the efforts of the besieger. The proper transportation of the large amount of material required by the siege operations, depends upon the efficiency of the railroad. Not to follow the existing railroads, means either the construction of new standard-gauge track with a consequent costly delay or the hasty building of a narrow-gauge railroad of comparatively low efficiency. In the usual case, then, the location of the existing railroads will be the preponderant consideration in the choice of the front of attack.

The ''front of attack'' finally selected will include one or generally more detached forts, will conform as nearly as possible to the above conflicting requirements, and will be so chosen that its capture will decide the possession of the place.

All knowledge of the front selected should be kept from the enemy as long as possible. However, to long deceive the besieged as to the real direction of the attack will be impossible, unless the assailant has such a superiority of numbers as will enable him to make several different attacks, finally concentrating on the one that promises earliest success. Usually the besieger will be content to maintain superiority along a single line, though this be known to the besieged.

When the ''front of attack'' has been decided upon it is the duty of the chief engineer of the siege to submit to the commander-in-chief a concise written project, accompanied by a large scale map in duplicate. This project for the general conduct of the attack should cover:

1. The location of artillery and engineer parks and communications thereto and therefrom.
2. First parallel and the approaches thereto.
3. Approximate location of the successive positions to be occupied.
4. Artillery position (as selected in conjunction with the chief artillery officer).
5. Covering line for the artillery position.

Once this project and the accompanying map have been approved, they are kept at the headquarters of the siege commander and the daily changes and the progress of the attack are there entered upon the duplicate map.

The advanced depots will be located as far forward as is consistent with safety, good communication from the rear and good supply therefrom.

The location of the first parallel and the approaches thereto will generally be determined by the natural features of the ground. Before it can be occupied, the advanced works of the enemy in the zone of attack or such collateral works as enfilade the proposed position must be captured and the besieged driven back to his main line.

The location of the successive positions in the project is approximate and merely serves to indicate the general lines along which the attack is to be prosecuted.

In selecting the sites for the batteries, the following considerations govern:

1. Effective fire.
2. Concealment.
3. Ease of directing fire.
4. Facilities for supplying ammunition.
5. Possibility of employing enfilade fire.
6. Facilities for the command and cooperation of the various batteries.

Before the batteries can be built and armed, the advance of the infantry must be pushed out to a covering position in front of the site selected for the artillery position. How far this covering force can be pushed out will depend on the configuration of the ground and the activity of the besieged. The deployment of the artillery and the covering force will be extensive enough to bring a concentrated fire on the works and to envelop the ''front of attack.'' The artillery position will be within effective range of the fortress, but not too close to the covering infantry, which pushes as far to the front as possible. As soon as the covering position has been captured, the infantry and engineers immediately proceed to organize it to resist an offensive return. There is great need of progressively and rapidly reenforcing and strengthening the covering position, because at this stage the defender's artillery can devote itself almost exclusively to this line.

While the infantry and a portion of the engineers are engaged in front capturing, organizing and defending the covering line for the artillery, the artillery and other engineers are busy bringing up the siege artillery, manning and arming the batteries.

As it is impossible to throw up emplacements which can give complete protection against the defender's heaviest ordnance, a great deal of dependence must be placed in the security that comes from concealment. Recent progress in the navigation of the air by aeroplanes and dirigibles, and their employment as air-scouts has increased enormously the difficulties of concealment. To combat this difficulty the besieger must be prepared at this stage, and at all subsequent stages, to dispute the supremacy of the air with more powerful fleets of air-craft than the defender can employ, as well as by attacking reconnoitering air-scouts by the fire of especially constructed ordnance.

Sunken batteries, without parapets or with parapets of minimum height, which take advantage of the folds in the ground, best fulfill the requirements as to concealment. When complete concealment is impossible, cover should be provided to localize and minimize the effect of hostile shells, protect against field-gun fire and afford the battery means of defense against rifle fire. The amount of cover and concealment are entirely local matters. The type batteries that may be laid down in regulations must be varied to give the greatest practical amount of concealment and cover. When all the batteries can not be concealed, those which are hidden are first armed; later, the others are armed behind masks which are withdrawn just before opening fire. Sometimes decoy batteries are placed openly, as if imperfectly concealed, at extreme ranges to draw the fire of the fortress while closer batteries are being constructed. Before fire is opened, alternative positions are selected and their preparation begun, so that should the first position become untenable, a new position can be occupied with a minimum of delay. Magazines with at least one full day's supply of ammunition should be constructed on the flanks of batteries and not more than 100 yards distant, connected thereto by splinter-proof trenches. Once the batteries have opened fire, an enormous expenditure of ammunition will be required in order that firing may go on without cessation. Therefore every effort should be made before the opening of the bombardment to provide for its uninterrupted supply.

In the construction of the platforms, involving, as it may, timber, steel and concrete, it is essential that the greatest care be taken; for the best and quickest final results will be obtained by employing time in making those refinements which will increase the accuracy of fire of the batteries.

Wire entanglements and other obstacles should be provided in front as a protection against surprise and as an aid in the repulse of infantry attacks.

After the infantry has secured itself in the covering position, further progress is out of question until the batteries are armed and ready to fire. Fire should only be opened when everything is prepared and the opening by all the batteries can be simultaneous. The batteries should be completed and armed. Supplies and ammunition must be ready and their uninterrupted replacement assured. Two distinct and separate telephone systems should be installed, one connecting the various artillery positions with the artillery commander; the other system sufficient for the control of the other units. The necessary measures for the observation and direction of the fire should be taken. When these preparations have all been made, the batteries simultaneously open fire against the fortress artillery and detached forts.

Everything that has been accomplished up to the moment when the artillery is ready to open fire has been in the nature of preparation. The opening of fire by the artillery is the signal for the infantry to push boldly forward. Henceforth every effort must be made to conduct the attack without relaxation or cessation up to the moment of the capitulation of the place. A success at any point, any position captured must serve only as a new point of departure for another forward step. There must be a relentless vigor in pushing troops and works forward to successful issue of the siege.

The purpose of the artillery bombardment is to assist the attacking infantry by silencing or at least holding down the fortress artillery; to wear out the garrison and thus hasten the capitulation; to weaken defensive measures by destroying splinter-proofs, bombproofs, magazines, stores, and communications within the fortress; to prevent the completion of new works or the repair of old ones; to harass the civilian population so as to bring pressure to bear upon the fortress commander and thus hasten the surrender of the place.

To attain these various objects, the artillery must avail itself of all the different weapons of its arm and all manner of fire. Against the direct-fire guns of the defense, either in the open or protected by cupolas or casemates, must be concentrated the fire of the besieger's heaviest calibers. The advantage of the initiative, which lies with the besieger, will make it possible for him to concentrate the fire of large masses of artillery in dispersed positions against comparatively few guns on the ''front of attack.'' The besieged, from the very nature of their problem of protecting from all directions, must keep their guns disposed more or less on the different fronts.

To destroy communications, break down overhead cover, destroy magazines and storehouses, the curved and high-angle fire of howitzers and mortars will be employed. The use of high explosive shells for this purpose gives results important for their moral as well as their material results.

The completion of new works and the repair of damaged works must be prevented by howitzer and mortar fire. In this connection and more especially to prevent the approach of supports and reserves, shrapnel fire will be brought into play. Although shrapnel is powerless against material cover of the most meager description, the moral effect of the shrapnel burst against unprotected personnel will find many opportunities for successful employment.

In the siege of Port Arthur, the Japanese brought artillery of every sort and description into action. Not only did they avail themselves of the 5-inch and 6-inch caliber howitzer and siege-gun normally in the siege train, but they went to the extreme of mounting the powerful 11-inch howitzer. Nor was any caliber too small to have a function in the artillery attack. Field guns were pushed up to nullahs and concealed positions within 1,500 yards of the Russian works; mountain guns found constant employment in the saps and advanced parallels.

Having once opened fire, the artillery must play its part at all subsequent stages of the siege, preparing, supporting and cooperating in the efforts of the infantry and engineers to reach the position for making the decisive assault.

Supported by the fire of the artillery, the infantry will push on by a succession of forward movements and lodgments to a point where, owing to the unsilenced fire of the defender, further progress above ground is impossible. Advances are carefully prepared by reconnaissances made by officers' patrols which, in addition to locating the most practical and favorable line of advance, mark them so that if necessary they may be followed in the dark. Before the advance is taken up, especially at night, the leaders must all be oriented and know the direction of the movement. Instructed leaders, numerous and clear indices of direction, preceded by a careful and complete reconnaissance, will give good assurance of success in these advances, which will generally be made under the cover of darkness. The infantry advance silently and, having attained a new position, entrench at once. For the service of security, patrols, who must be careful to avoid masking the fire of the line in rear, are pushed well forward. If at any time the lines or patrols come within the beam of a searchlight, the men throw themselves on the ground and remain motionless, until instructed to move forward again. Reserves must be stationed in rear, ready to assist any portion of the line endangered by sorties of the enemy. In repelling sorties, opportunities will often be afforded for making a new step forward.

Even in the face of hostile fire, advances can often be made by detached groups, under the cover of heavy artillery and machine-gun fire and with the support of the remainder of the attacking line. Each individual is supplied with sand-bags or steel shields, in order to make a hasty shelter when he has arrived at the new position. When the first groups are established, others come up from the attacking line, supported by the fire of the remainder of the attacking line and the groups already in position. Immediately, covered communications with the rear are opened up and the position thus obtained is gradually strengthened.

During these advances, the sectors other than those of the attack must by every means cooperate and support the latter.

When further advance can only be made by a resort to trench work, sapping and mining, we enter upon the third phase of the siege. This includes all the remaining operations, whose main reliance is the shovel, which are necessary to bring the infantry to the point from which they can deliver the decisive assault.

The engineer now takes the most active part in the struggle. Protected by rifle and machine-gun fire and such artillery support as can be given without endangering the workers at the heads of the saps, the sappers must work their way up to the enemy's works and there bring about such destruction as will make feasible an infantry assault.

The besieger can expect to find a zone of from 600 to 1,000 yards in width swept by fire, and illuminated at night by searchlights. To cross this zone the engineer must drive covered paths through the earth close up to the enemy's works. These paths or approaches should be as numerous as the labor which they require will permit. In order to prevent enfilade by any portion of the defender's works, they are made zigzag, and every advantage is taken of the protection offered by dips, ravines, and other topographical features. By taking full advantage of favorable topographical features it is possible to greatly economize the labor connected with the trench work. After the approaches have been driven forward as far as possible, dependent on the activity of the enemy and the configuration of the ground, they are connected by the first parallel, a trench generally parallel to the enemy's lines on the ''front of attack.'' When the defender is not provided with searchlights, it may be possible for working parties to construct the first parallel by ordinary trench work under cover of darkness, the approaches being constructed at the same time or later to connect with covered positions in rear. New approaches will be driven from the first parallel, and subsequent parallels and approaches will be constructed to conform to the special requirements of the situation. New parallels will be constructed to comply with the general principle that the besieger's troops in the last completed parallel should be nearer to the head of the approaches than the besieged's most advanced positions, in order that in case of offensive returns by the defense, the advantage of distance will lie with the besieger. Other than as above, the distance between parallels will depend on the activity of the enemy and the configuration of the ground.

These parallels, each one a new lodgment nearer to the enemy, should be inconspicuous, though normally this will be very difficult to attain. Following the types laid down in engineering manuals, they should be traversed, recessed, and generally provided with head and overhead cover. They have two main purposes; at first, to be a protection to the approaches under construction, and later to serve as lateral communications between the approaches. To best fulfill these two functions, the requirements for a parallel are:

1. Cover foreground thoroughly with its field of fire.
2. Provide cover for the occupants from view and hostile fire.
3. Have sufficient width and depth for lateral communication.
4. Possess latrine and cooking facilities for the guard of the trenches.

The cross-section will vary with the above requirements, the character of the soil, and the time available for their construction.

In the distant stages, parallels and approaches may often be constructed at night by ordinary trench work. But as the siege progresses, sapping must be resorted to. This consists of advancing a trench by men digging away at its head. Sap work is a slow process at best and, as the advance depends entirely upon the ability of the men at the head of the sap, only the most fit physically should be employed. These, moreover, should be stimulated by short reliefs, by the assignment of definite tasks and by the offer of rewards to give a maximum of effort to this important work. In very hard ground small charges of explosives will facilitate operations.

The light field guns, mortars, and machine guns of the defense render sapping difficult, dangerous and costly. As a result, it can only be carried on at night and even then the hostile searchlights make concealment most difficult. The normal type of sap in ground which admits of excavation will be a deep narrow trench, without parapet. Such a sap should be at least 6 feet and preferably 7 feet deep. Provision must be made for disposing of the excavated earth by carrying it to the rear.

In rocky ground or where the ground-water comes close to the surface, parapets of sand bags or sand bags augmented by steel plates must be used. The difficulty of supplying material for filling the sand bags adds greatly to the hardships entailed by this method.

When the sap can be made partly but not entirely in excavation, the sap head is a movable one of sand bags and the excavated earth is used to give protection on the sides of the sap.

As the appoaches come close to the enemy's works, practically no progress can be made to the front by the use of zigzags without exposing the saps to the enfilade fire of the fortress. Recourse must then be had to traversed or blinded saps driven perpendicular to the attached work. The blinded sap will be the more efficacious when the sap-head approaches within range of the enemy's hand grenades.

The sap will be pushed close up to the trenches and obstacles of the besieged until finally the fire of the short-range mortar and hand grenades, together with the general activity of the defense, will make the advance by sap so costly and dangerous as to be prohibitive. If a position suitable for delivering the decisive infantry assault has not then been reached, further progress must be accomplished by mining.

During the time occupied by the mine operations, Coehorn's expedient of bringing mortars up into the last parallel will be resorted to. Short-range mortars and bomb-guns will throw high-explosive shell and bombs into the work, in order to detract attention from the activities of the miners.

Mine warfare is slow, dangerous, and uncertain. The besieger will not resort to subterranean attacks until he is compelled to by the failure of the sap. The aim of the mining operations is to place large charges of explosives to accomplish one or more of the following objects:

1. Produce a large crater at the surface of the ground to provide a shelter and lodgment for attacking troops.
2. Damage or destroy the works of the besieged above or below ground.
3. Destroy personnel or at least affect their *morale.*

In accomplishing any of these objects, the attack can expect to contend with the countermines of the defense. One guiding principle of mine tactics is to discover and destroy the enemy's countermines before he has had an opportunity of discovering those of the attack. By multiplying the number of mines, the disadvantages consequent to the skilful employment of the countermines may in a measure be counteracted. But the great amount of labor incident to the construction of mine shafts and galleries limit the use that can be made of this expedient. No effort must be spared to ascertain the location of these countermines and to make provision for the conduct of the attack in the case of their being fired by the defense before the besieger's mines are ready.

The attack will drive a series of parallel galleries starting from shafts or inclined galleries, embracing the entire front to be attacked. Some of these galleries will be false, so as to deceive the besieged as to location of the real mines. When the galleries have been driven as far to the front as the enemy's countermines, or have reached the point decided upon as most favorable for making a new lodgment or reached the position which promises success as the base of the infantry assault, overcharged mines are simultaneously fired at the head of each gallery. The charges should be so regulated that the succession of craters will form one continuous line of cover.

Before the mines are fired, every precaution should be made for:

1. Infantry to occupy and entrench crater.
2. Engineers to open and enlarge communications from last trench to line of craters.
3. Artillery fire, especially short-range mortar fire, machine gun and rifle fire trained to prevent hostile sorties against the crater.
4. Reserves, to be pushed rapidly forward to assist in the repulse of sorties.

At the instant of the explosion, when the besieged is fully aware of the direction of the mine attack, the miner must take immediate steps to break down or neutralize any countermines which the besieged may be on the point of firing. Hasty shafts, partly lined galleries and borings with hastily placed charges will be used to prevent the successful use of hostile countermines.

The science of military mining has been scarcely advanced at all by the wars of the past generation. The lighting of galleries by electricity, the use of compressed air in ventilation and the more rapid progress due to modern boring tools are all that differentiates military mining of to-day from that of Sevastopol. Yet the art of military mining continues to hold an important part in the modern siege. The siege guns attached to modern armies are unable to demolish the cover provided in the modern fortress. Therefore the miner must be prepared to carry on the advance, when the infantry and the sapper, though supported by the full strength of the artillery, are brought to a standstill. Port Arthur, with cover far below the standard required of the modern fortress, confirmed the necessity for the use of the mine in the final stages of the advance to the assaulting position.

When the infantry has been conducted to a favorable storming position at the foot of the glacis by sap, or when a practicable breach has been made in a work of strong profile by mine, the siege enters upon its fourth and last phase, the preparation and carrying through of the assault to the capitulation of the place.

If the assault is to be made from a storming position outside the obstacles, without recourse to mining, it can only hope to succeed when the previous operations of the attacker have shaken the power of defense of the besieged. Even under such circumstances the assault can not be too well prepared.

The assaulting position must be so constructed as to protect the troops that assemble there against the close fire of the defender; provide cover for the attacking columns during their approach to the position; and facilitate their departure therefrom when they move to the attack.

Previous to assault, all information possible must be obtained by engineer officers as to location of entanglements, abatis, palisades, etc., the width and depth of the ditch and the character and location of the ditch defenses. This information, as well as the general scheme for the assault and their own individual objectives, should be communicated to all the officers of the assaulting columns.

The assault order should contain the following information:

1. Designation of the hour of the assault.
2. Division of troops and commanders.
3. Missions of the different assaulting columns.
4. Instructions for the accompanying engineers.
5. Instruction to the artillery.
6. Ammunition supply.
7. Subsistence arrangements.
8. Where the chief can be found.

The assault will follow the usual combat tactics of the infantry, with provisions for supports, reserves, flank protection, artillery support, ammunition supply, etc. Each assaulting column will be made up as follows:

1. Engineers to go ahead to clear away obstacles.
2. Infantry in successive lines to carry the attack forward.
3. Working parties to prepare captured points against offensive returns.
4. Artillery to destroy captured guns or to turn them against the besieged.
5. General reserve.

Surprise is an important factor in an assault. Therefore the character of the artillery bombardment should not change as the hour for the storming approaches, in such a manner as to indicate to the besieged the imminence of the assault.

What is the best time for the assault? To make a night assault the offense must dispense with his artillery support, and the usual advantages of the night attack are also more neutralized by the searchlights of the defender. Moreover, the sap will have brought the attacker to within striking distance, which is about all that is ever expected to be accomplished under the cover of darkness. An attack delivered a few hours before dark with sufficient time left to carry through a successful assault has much in its favor. In this event, an offensive return made by the defender to recover any position lost during the assault will have all the disadvantages of a night attack, whereas the withdrawal of the assaulting column in case of repulse will be favored by the coming of darkness.

Against a place which has not been shaken by the artillery bombardment or by the ravages of starvation and disease, except under conditions most favorable to the attack, such as naturally covered approaches, defenses poorly located or great numerical superiority of the besieger, the final assault delivered from any position in front of the obstacles has but little hope of success. Such assaults may, however, be made merely to test the temper of the besieged or as false attacks to deceive the enemy, when the real assault is finally delivered or for the purpose of making an advanced lodgment in the event of the failure of the primary mission. This lodgment, because of the saving in time and labor required by continuous sapping, may make such assaults worth while. The repeated failure of such assaults, however, although there may be slight advantages gained by each, can not fail to injure the *morale* of the besieging troops.

Quicker, surer results will usually be obtained by sapping and mining through the obstacles right up to the counterscarp. After blowing down the counterscarp and masking or destroying the ditch defenses, the assailant has every hope of bringing the attack to a successful conclusion. The conduct of the storming columns will conform to the principles laid down above for the attack from a position outside the obstacles.

The following description of the Japanese capture of Fort Erhlung-shan, as described by Colonel Kuhn, is typical of the operations that culminate in the attack by mine.

''The front glacis was simply honeycombed by the Japanese saps which covered the entire available area. These saps were of great depth, at least 7 feet, and quite narrow.

''After the Japanese had carried the glacis trench, they sunk a mine on the back of the counterscarp gallery at the northeast salient and blew in the roof of the same. A large mine was then lowered into the chamber, blowing out the entire front of the chambers ——. They also sunk two mines behind the counterscarp of the face, blowing in the same and partially filling the ditches. Five galleries and a like number of mines were then placed under the front parapet, which was successfully blown up on December 28, and the work captured. The Russians fought most obstinately defending the fort, first from the heavy gun line, then the gorge, and finally from the sand-bag parapet on the gorge glacis. A final remnant of the Russian garrison is stated to have shut themselves in the east gorge casemates and to have refused to surrender until they were smoked out by inflammables thrown through the loopholes and ports.''

In the final stages of the attack, whether the assault is made from the last sap or is to follow the explosion of mines, the bomb gun, hand grenades and machine guns of the defense will increase the difficulties and the dangers of the assailant. The effect of hand grenades is local, but nevertheless very demoralizing. Machine guns trained beforehand to cover all the approaches are especially effective against the close attack and in defense of the ditch.

The assailant will fight hand grenades with hand grenades, especially trained troops being assigned to this duty. The machine gun and the machine-gun casemates will be assailed by mine or will be opposed by machine guns and mountain guns brought up through the saps for this purpose.

Artillery bombardment, destructive effect of mine explosions, hand grenades and rifle fire all have a part in the final result, the capitulation of the fortress. But the complete capture of any work is usually the work of the bayonet. When the practicable breach has been made, then the infantry must rush in and take the place by a hand-to-hand encounter. Steel and explosive will assist the infantry to within reach of victory, but the last touch must be the human impetus. Complete possession will call forth a final test of nerve and sinew, flesh and blood, before the defender will submit to the inevitable.

The withdrawal of the enemy from any of his detached forts is far from completing the labor of the attacker, although the final outcome is practically certain. The instant of success must be utilized to begin preparations to hold the place against the offensive return which will be made by the reserves of the fortress. The details of the infantry and engineers for this work must be made beforehand. The remainder of the infantry and engineers may push on after the defeated defenders or assist in the organization of the captured place. If the first line of the attack push on the reserves must hasten to occupy and organize the captured work.

If a second line has been prepared by the besieged to which he can withdraw upon the fall of the first line, operations similar to the above must be commenced against the new line, using the captured works as a base. However, when the main line has been taken, the end is in sight. Extensive operations against a second line or against the enceinte will scarcely be necessary after the besieger has brought up his heavy artillery to the captured positions and directed them against the nucleus.

Upon the capitulation of the fortress the besieger must be prepared to occupy the place with a force strong enough to control the prisoners, establish and maintain order among the civilian population, and to restrain the soldiers, who, under the excitement and relaxation due to success, will be tempted to disorder, pillage and abuse.

THE DEFENSE.

The purpose of a fortress has been variously defined: to give time for the mobilization of the field armies; to act as a barrier behind which defeated armies may retire and reorganize; to act offensively against an invading enemy's line of communication; ''to assist in the stubborn defense of a point until the end of the war; to defend a given strategical point with the smallest possible garrison for the longest period against a numerically superior force of the enemy.'' Throughout these various definitions, runs the same general conception of the proper use of a fortress; to delay the enemy and gain time for the strategical operations of the field armies.

The rôle of the garrison in gaining this delay is defensive. The best preparation that the defenders can have for a successful defense is a knowledge of the character of the tasks imposed upon the attack and the methods which the besieger will employ to accomplish his purposes. Therefore in this paper, although the siege problems of our Army will be more often defensive than offensive, much more space has been devoted to the general principles of the attack than will be used in discussing the defense. Since the defense must always oppose the lines of attack adopted by the attacker, the general conduct of the besieged is dependent in a great measure on the operations of the besieger.

The successful defense of a fortress or of a position which is so strong as to force the attack to adopt siege methods, will always be one whose real spirit is offensive. Bold initiative and unexpected action on the part of the defense is the best means of delaying and retarding the besieger's advance. The complete defense of a fortress consists of two conflicting elements: a power of passive resistance which will compel the besieger to exert himself to the utmost to conquer the works; and in addition, as General Von Bessler states, the fortress must possess a high degree of ''striking power.''

The passive resistance of a fortress is largely a matter which can be attended to in peace times and in the period intervening between the outbreak of war and the hostile movement against the place. No technical means should be spared to give the fortress the strength of passive resistance which comes from armor, concrete, strong profiles, numerous obstacles and thorough preparation. The quality of the passive defense, political matters aside, will be a function of the ability of the engineer in peace-time and of the resourcefulness and ingenuity of the commandant of the fortress from the time the fortress is in danger until the end of the siege. The active defense will depend on the measures taken and the offensive military spirit displayed by the fortress commandant from the moment that the place becomes of immediate strategic importance. This part of the defense, and it is by far the most important, will be a matter of sending out advanced detachments, organizing advanced posts, commanding an extensive foreground by well-placed guns and a mobile reserve, resorting to sorties and offensive returns and, above all, the possession of that spirit which Carnot, at the beginning of the Nineteenth Century tried to instil into the French fortress defenders, ''Fight to the last.''

Everything depends on the fortress commander. His courage, foresight and determination will be reflected in the labors of all of his subordinates. He must be possessed of the versatility which will avail itself of anything new or old that may delay or defeat the besieger. He must have the audacity to dare try for success under the most desperate or impossible conditions. He will anticipate the besieger's offensive; drive counter-approach against his saps; countermine against his mine; and make counter-assaults against his assaults. He must remember that the surrender of the fortress one day before its fall is inevitable, may have a vital influence on the campaign of the field armies in other portions of the theater of war and may be disastrous to the fortunes of his country.

That the commandant of the fortress may cooperate to the fullest extent with the field armies, he should possess secret instructions as to the *raison d'etre* of the fortress. The war department or the supreme commander should keep him informed by wireless, carrier pigeon or by messenger from time to time during the siege, what is still expected of the fortress and what effect, if any, the operation of the field armies should have on the nature of his defense.

The commandant should advise with his subordinates from time to time, but the ultimate decision and responsibility rests with him alone. Above all, he must bear in mind that ''A council of war never fights.'' He must not, purposely or otherwise, delegate his command, authority, or responsibility to such a council.

It is difficult to conceive of the defense of a large fortress which will not impose upon the fortress commander all the dangers and difficulties incident to a large civilian population. In this connection, he must be prepared, through his staff, to solve the following problems on the outbreak of hostilities:

1. Exclusion of certain classes of persons from the fortress.
2. Employment of desirable civilian labor in the construction and repair of works, communications, etc.
3. The enlistment of civilians into volunteer organizations; their equipment and training.
4. The control of the water supply with special provisions for a reserve supply; the regulation of the use of such a reserve supply.
5. The collection and storage of all food supplies; control of milk supplies for infants; the collection and inventory of all medical supplies; the regulation of the distribution of the above to the civilian population.
6. The adoption of special fire, police, and sanitary regulations.
7. The control of all sources of information and lines of communication; establishment of a censorship of mail, telegraphic and press despatches.
8. The proclamation of martial law.

In addition to the above, which are in the main precautions to be taken because of the civilian population, the peace plans of the fortress commander should embrace the steps necessary to bring about the following at the outbreak of war:

1. The collection and storage of all arms and ammunition of every description.

2. The collection and employment of such animals and vehicles as can be used in the transport service.

3. The collection and storage of all tools and materials which can be used during the siege.

On the approach of hostilities or after hostilities have commenced, extensive changes and a vast amount of labor will be required to change from peace conditions to a state of preparation suitable to resist a siege. The principal things to be accomplished are:

1. Field of fire must be entirely cleared.
2. Obstacles must be constructed.
3. Necessary field works must be constructed for the defense of the intervals, and the occupation of advanced positions.
4. Additional bombproofs, covered communications and head cover must be provided.
5. Emplacements must be armed.
6. Roads and railroads must be constructed or put in condition to meet the increased demands.
7. Telephonic, telegraphic, and wireless communication must be amplified.
8. Preparations for the necessary demolitions must be made.

To derive all the advantage that accrues from the occupation of a previously prepared position, it is essential that the scheme of defense be thoroughly organized. The plans of the defender should be in such shape and so well understood by those who are responsible for their execution, that the entirely unexpected outbreak of hostilities may not catch the defenders of a fortress napping. Whatever faults there may be in the defense should be due to political and financial causes, rather than to military unpreparedness. The lack of political or financial support is no excuse for not accomplishing the most with the means available.

In the organization of the fortress for defense, it must be remembered that the brunt of the defense will eventually fall on the girdle of detached forts, which form the main line. The maximum effort should be put forth to strengthen this line.

Invariably, advanced positions will also be prepared for the occupation of infantry and artillery, who will dispute with the besieger the possession of the foreground. To begin with, these works will partake of the nature of field fortifications, but when time is available they will be strengthened into semi-permanent works. As far as possible, they will be so located as to afford each other mutual support and if practicable to receive support from the artillery of the main line. Care should be taken that they do not mask the fire of the main works or possess features which, in the event of their capture, can be turned to favorable account by the enemy.

After the direction of attack has been determined, a second line may be established in rear of the ''front of attack.'' The French regulations prescribe such a *position de soutien,* and some other foreign regulations advise its use. There are two important arguments against such fresh positions. They result in a division and consequent weakening of the artillery, since some of the artillery must be left in the rear position; they are very apt to result in the too early retirement of the troops from the main line. Machiavelli with much truth wrote many years ago, ''I maintain that there is no greater danger for a fortress than rear fortifications whither troops can retire in case of reverse; for once a soldier knows that he has a secure retreat after he has abandoned the first post, he does in fact abandon it and so causes the loss of the entire fortress.'' The matter would seem to be more or less dependent on the temper, spirit, and determination of the troops. Where well disciplined troops can be depended upon to fight each line to the utmost, cases will occur when the same amount of time and labor expended on a second line would have a greater effect in delaying the capture of the fortress than a like expenditure on the main line. In such a case a retrenchment should undoubtedly be provided. The preponderance of military opinion is, however, that in the general case the final decision should be sought at the main line of detached forts, to strengthen and defend which no effort should be spared.

The distribution of the troops assigned to the defense of a fortress conforms to the general principles that govern the distribution of troops in a defensive position as laid down in Field Service Regulations. The garrison is divided up into sectors and a general reserve.

The commander of a sector of the defense will command all the troops, infantry, artillery, and engineers in his sector. From his mobile troops, he must provide the outposts, interior guards, and local sectional reserves for his section; and must occupy and prepare for defense all important tactical points in his section. He must be prepared to defeat all minor attacks against his position and hold in check all attacks by superior forces long enough to enable the general reserve to be brought up in support. In addition, he must assign a portion of his command as a permanent garrison of the forts, batteries, and intervals.

The general reserve will furnish troops for the delaying operations against the enemy while he is still at a distance; they will make offensive sorties, counter-assaults and offensive returns; they will reinforce those portions of the front that are attacked by superior numbers.

The essential feature of defensive fortress warfare consists in using all possible means of prolonging the defense, yielding the ground to the besieger inch by inch. To carry out this duty of delaying the enemy at every stage of his operations, the defender must act on the offensive at every opportunity. Advanced detachments, advanced posts, sorties, counter-assaults, and offensive returns must be employed. The actual defense must commence long before the defensive weapons of the main line can be brought into play. The defender will endeavor to gain contact with the besieger as soon as possible. For this purpose, strong detachments are sent out from the general reserve. The mission of these detachments will be to harass the besieger, threaten his communications and cause his early deployment. The extent of the delay caused by these detachments will depend on the numbers that can be spared for this duty, and the offensive spirit of the detachment commander. Keeping the enemy under constant observation, occupying successive positions as long as possible, they will further delay the besieger's advance as they fall back, by destroying all fords, bridges, and railroads. The conduct of these detachments will conform to the principles laid down in Field Service Regulations for a rear guard in action.

When the besieged has been forced back to his advanced positions, he will endeavor to prevent the completion of the line of investment. Outposts will be pushed out to the front to prevent hostile reconnaissance and to obtain information. Aeroplanes and dirigibles will attempt to discover the location of the parks and the position selected for the besieger's artillery. The infantry will make counter-attacks and offensive returns to dispute with the besieger the ground necessary for the location of the hostile batteries and their covering infantry. The artillery of the defense will fire on the camps, railroads, detraining points and parks. Every effort will be made to discover the "front of attack."

When the "front of attack" is known, the distribution of troops is changed so as to reinforce the threatened front, holding the other fronts with a minimum of troops. The artillery will take position to assist in the defense of the advanced positions on the endangered front. Sorties and demonstrations will be made by parts of the general reserve to interfere with the construction and arming of the besieger's batteries. During this stage, before the attacking artillery is able to support its infantry, the fortress artillery must inflict all possible damage on the infantry and engineers who will be organizing the covering position for the artillery. The fortress artillery should also endeavor to locate separate batteries, concentrating on them and destroying them in detail. Every opportunity should be taken to fire on any infantry target that exposes itself. The batteries of the sectors adjoining those of the front of attack should have especially favorable opportunities of attacking the hostile infantry during its advance.

If the besieger carries out his attack in a logical manner, the garrison of the advanced works will be obliged to retire; they should put up the most stubborn defense, and assisted by portions of the general reserve, make every effort to retake a captured place at the instant that the enemy has been thrown into confusion by his success. Should the attacking artillery apparently have the best of the artillery duel, the fortress artillery will not be sacrificed at this stage, but portions of the artillery will be withdrawn to safe places to be used against the close attack, when the besieger's artillery is at a disadvantage.

Against the close attack, the defense must be especially vigilant at night. The obstacles must be closely watched against raids by the opposing engineers. Patrols should be sent out at night to discover the enemy's progress. Searchlights will endeavor to locate the besieger's working parties and light them up for the fortress artillery and machine gun fire. Sorties in force should be made against the sap heads. The use of machine guns, bomb guns, hand grenades and short-range mortars should delay the sapping operations of the attack. No advanced trench should be given up until the last moment and then attempts should be made for its recapture. Counter-approaches should be driven against the hostile saps, care being taken that they are enfiladed from the fortress so that the besieger can make no use of them in case of their capture.

As the heads of the besieger's saps draw nearer, the countermining system should be perfected and manned. When the besieger has been forced to resort to mining, the defenders of the fortress have gained an important point in their efforts to delay the advance. As soon as there is danger that the enemy has taken to mining, listening is resorted to in order to gain an advantage by firing the undercharged countermines before the attacker's mines are prepared. Although the difficulties of determining direction and distance underground are considerable, experienced listeners can give a very good account of operations at a distance of over 20 feet. When the hostile mine or gallery is within the radius of rupture of the countermine, the latter is fired in order to delay the attack by breaking in his galleries, filling them with poisonous gases, or causing the detonation of the attacking mines before they are completely prepared. Care must, however, be taken to avoid charges so great as to produce craters and thus be of assistance to the enemy, unless the object of the countermine is to destroy a lodgment already established above ground by the besieger.

Whenever the attack succeeds in firing his mines, the defender must do his utmost to prevent the occupation of the crater and the further efforts of the besieger to start new shafts and galleries. Concentrated artillery fire, machine gun and rifle fire, and showers of hand grenades must be poured into the crater. At the same time sorties in force should be made before communications with the trenches in rear have been fully established. Counter-mines which are advantageously located should be fired.

The end of the besieger's mining or sapping operations will find him in the position for the assault. As the assaulting columns leave the position of attack, the fire against them must be redoubled. The adjacent works and collateral batteries must bring the full weight of their concentrated fire on the advancing lines as long as possible and then endeavor to prevent the approach of the supports and reserves. The infantry of the defense will employ fire-action as long as possible and will then advance to meet the enemy with the bayonet. The general reserve will assist to the last man, aiding the defense by counter-assaults against the flanks of the advancing troops, or by helping directly in the repulse of the assault.

If the assault is successful, the defenders fall back to the *position de soutien,* if such has been prepared, and renew their stand. In every event, the defense is continued to the last extremity, surrender coming only when nothing else is possible.

CONCLUSION.

What are the needs of our Army that we may be properly prepared in the strategy, the tactics, and the technics of siege warfare? Some argue that the study of fortress warfare is an unimportant part of a military education and that a minimum of attention should be paid to this subject. It is indeed true that we will not have the need of the extensive preparation that is required of the European, especially the Continental armies. But no one can foretell the character of the problems of our next war and promise an absence of siege operations. The student of siege warfare may never be given the opportunity of carrying an offensive attack through all the stages of the regular siege to a successful conclusion. He may never be so unfortunate as to be obliged to stave off the attack against the provisional works which will attempt the land defense of our seacoast forts. But in any active operations, he will certainly find in the attack and defense of positions protected by field fortifications problems so similar to those of the siege that the lessons learned in the study of modern siege warfare will find constant application.

I find myself entirely in accord with the following prediction, made in *Studien zur Kriegsgeshichte und Tactik IV:* "The future will probably bring with it a closer connection between field and fortress warfare; a modern army must henceforth be always ready for the latter. Inadequate preparation in this subject, which appears constantly throughout military history, is likely in the future to have more severe consequences than in the past."

No officer of the infantry, artillery, or engineers can afford to be unfamiliar with the operations which characterize the modern siege or with the duties in connection therewith of his special arm.

If the country is not to add another to the long list of those that went into war and suffered disastrously because of the lack or inadequacy of their preparation in the subject of siege warfare and if it is to avoid the possible consequences of such delinquency, the following works must be accomplished:

1. Our higher officers, General Staff, Infantry, Artillery, and Engineer officers must be brought to a realization of the growing importance of the study of the modern siege.

2. A chapter should be prepared for our Field Service Regulations devoted to the general principles of siege warfare and prescribing the conduct and duties of the higher commanders, staff, infantry, artillery and engineers, in order to secure that coordination and cooperation which are essential elements of success in siege operations.

3. Infantry, field and coast artillery drill regulations should prescribe the specific duties of each of these arms when engaged in siege operations. The Field Artillery Drill Regulations should cover the employment of all calibers up to the 3.6-inch gun and the 4.7-inch howitzer. The Coast Artillery Drill Regulations should cover the duties of the foot artillery in siege operations on the offensive or the defensive. The regulations should embrace the employment of the 4.7-inch gun and the 6-inch howitzer, and of such other higher caliber ordnance as may be developed solely for siege purposes. These regulations should also provide for the possibility of the employment of the regular coast defense armament as a substitute for, or as an auxiliary to, the siege artillery, with which weapons we can always expect to be but poorly provided, because of the more pressing needs for field artillery.

4. The Ordnance Department should design and build siege artillery corresponding to the Krupp 21 cm. siege mortar or the Schneider 28 cm. siege howitzers. These pieces should be provided on semi-permanent mounts, each unit to be possible of transportation by two or more carriages. Such large caliber siege pieces should be turned over to the Coast Artillery. They could be employed to augment the permanent coast defense armament in resisting naval attack, especially covering landing places, but principally they would be available for use by the Coast Artillery when the latter was operating in its rôle of foot artillery in siege warfare. These two duties of the Coast Artillery would probably never conflict. When one coast was acting on the defensive, these transportable pieces could be taken by railroad from the other coast for offensive or defensive use. When siege operations were to be conducted beyond our borders, a very large proportion of our Coast Artillery would be released for this important and attractive duty, in which their special talents and training would not be wasted, as they are when Coast Artillery is converted into emergency infantry. Such siege pieces could be used both offensively and defensively in siege operations, besides being of considerable power in resisting the attack of permanent fortifications by hostile fleets.

5. It should be a peace-time duty of the Coast Artillery in preparation for the war-time rôle as foot artillery to thoroughly familiarize themselves with the terrain in the vicinity of their stations, over which the offensive and defensive operations of the attack of the land defences would take place. Not only should the Coast

Artillery officers possess themselves of an intimate knowledge of the artillery positions which will be occupied by the defense, but they should thoroughly acquaint themselves with favorable or possible locations for the attacking artillery. In this connection, also, the preparation of range-tables and of maps divided into squares and zones, and the collection, digesting, and recording in a usable form of the various necessary data, which is now so thoroughly and excellently done for the water areas, should be extended to the land defense areas in order to ensure the most efficient control of the siege artillery in defense of the land fronts.

6. The portion of the Engineer Field Manual which is devoted to siege operations should be amplified, or it should better be augmented by a treatise which could be used as a text. This text should bear the same relation to the Engineer Field Manual as does Fiebeger's Field Fortification. In addition to the matter already included in the Engineer Field Manual, it should embrace the strategy and tactics of the approach, investment and sap; the tactics of the mine attack; the duties of the Engineer troops in the close assault; the offensive and defensive employment of searchlights, aeroplanes, and dirigibles; the duties of Engineer officers and the conduct of Engineer troops in the defense of a besieged position; the tactics of the counter-approach and the counter-mine; the organization of the telephonic, telegraphic, and wireless communication both on attack and defense; the organization of railroads and other transportation facilities; the attack and defense of barrier forts.

7. A portion of the maneuver period should be devoted to the actual occupation by troops of the defensive positions as laid down in the various land defense projects. Other troops should be assigned to the attack of these positions. This attack should include all the operations of the approach and investment, the attack of advanced positions and the location of the artillery. The Engineers should submit their plans for attack and defense, actually lay out the parallels and approaches, make requisition for the necessary workmen and post them under the conditions simulating the difficulties of the actual siege. That the complete realization of such ambitious maneuvers is hardly to be hoped for no one better appreciates than the writer. But any accomplishment in this direction would serve the double purpose of training our mobile Army in the important duties of the siege, both offensive and defensive, while at the same time it would permit the cor-

rection and perfection of the purely theoretical land defense projects under the most favorable circumstances and as a result of tests which would show up weakness that otherwise might not be discovered until they developed during the inauspicious period of actual hostilities.

The New Welland Ship Canal*

THE THIRD AND GREATEST WATERWAY TO JOIN LAKES ERIE AND ONTARIO—ITS GENERAL DESIGN AND COURSE—HISTORICAL NOTES RELATING TO OLD WELLAND CANALS.

Among the big engineering undertakings started during the present season there are few that excel in size the structure which is to replace the canal which connects Lakes Erie and Ontario. The Welland Canal now in use has, since its construction, been known as the ''new'' canal, in distinction from the original waterway which is now historically referred to as the ''old'' canal, the work under contemplation therefore constituting the third. The original and present canals followed a route from Port Colborne across the Niagara peninsula, practically paralleling each other at the northern end, entering Lake Ontario at Port Dalhousie. The original canal was commenced in 1824, and completed in 1833, the line following very closely certain water courses to facilitate construction, making the length 27½ miles. This canal contained twenty-seven locks, twenty-four of which were 150 by 26½ feet, and the other three 200, 230 and 270 by 45 feet, respectively. The depth of water on the sills was 10¼ feet, with a total lift of 326¾ feet. The initial construction of these locks gave a depth of 8 feet, the increase of 10¼ feet being a subsequent change. The present canal was commenced in 1872, and completed in 1887. The route at the northerly end was slightly changed to the east near St. Catharines, the canal coming out into Lake Ontario at the same point as the original one. The locks are twenty-six in number, 270 by 45 feet, with a depth of 14 feet over the sills.

The route to be followed by the proposed canal, beginning at the southern terminus—that is, at Port Colborne, is the same as that of the present canal as far as Thorold, from which point it will deviate to connect with a harbor which will be constructed at the Lake Ontario end, some 3 miles east of the present Port Dalhousie outlet, this diverging portion being about 8 miles in length, and passing in almost a straight line through Merritton to the lake. The section of the existing canal between Thorold and Merritton will therefore be abandoned, but it is the intention to use the portion of the present canal between that point and Port Dalhousie as an auxiliary.

The present canal is made up of twenty-five locks, each 270 by

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*Reprinted from *The Canadian Engineer,* August, 1913.

45 feet with some 14 feet of water over the sills. The total length of this canal is 26¾ miles.

The new canal will have seven locks, each of 46½-foot lift, 80-foot width, and sufficiently long to accommodate a vessel of the length of 800 feet. It will be 25 miles from lake to lake and will cope with a difference of level of 325½ feet between them. The minimum depth of water over the miter sills of each lock will be 30 feet. The bottom of the canal will be 200 feet in width, and although the depth will ultimately reach 30 feet, the present excavation will stop when 25 feet is reached, further deepening being looked after when occasion arises by dredging out the reaches to the required depth, according to design. The lock walls will be 82 feet high above the top of the gate sills, and including the necessary foundation work required below this level two of the locks will have walls 100 feet high. The lock gates will be of the single-leaf type, swinging on a hinge at one side of the lock and resting in a notch cut in the opposite wall, a single leaf thus spanning the whole width of the lock chamber. The gate at the foot of each lock will be 83 feet high and 88 feet long, and will weigh about 1,100 tons. The valves and culverts in the walls will of large dimensions and will permit of the lock being filled in less than eight minutes. This will mean that the time of passage through the canal will be reduced much below that required at present. The time of lockage of the present canal is from ten to twenty minutes per lock. In the new canal there will be eighteen fewer locks, and the saving in locking time will be in the neighborhood of three hours.

PORT COLBORNE DEVELOPMENT.

In Fig. 1 will be noted a proposed new breakwater off Port Colborne, to prevent a disturbance of harbor water, with which the present conditions have to contend, as the present breakwater is insufficient in effect owing to size and location. The new breakwater will consist of an immense rubble mound of stone from the excavation north of Port Colborne, and will terminate in timber and concrete headblock located some 2,000 feet farther out in the lake than the present breakwater.

The outer harbor at Port Colborne has now a 22-foot depth of water at ordinary stages of the lake, which is as much as is available at most of the other lake ports and in the channels connecting the lakes at the present time. The deepening of this portion of the harbor may be left for a few years until the connecting channels in the lakes allow deeper navigation. The inner harbor will be excavated to the new depth proposed, and the old locks and regulating weir now in the center of the village will be entirely removed.

From Port Colborne to Humberstone the rock cut will be deepened and widened on the west side, and just below Humberstone a new cut will be made across the point now fronting Rameys

Bend, materially straightening the canal. The excavation from this cut will be principally rock, and will form suitable material for the breakwater in Port Colborne Harbor.

A guard lock will be built in the rock cutting a short distance below Humberstone, and when this new cutting is ready for navigation a regulating weir will be built across the abandoned portion of the present canal, which will be used as a by-pass to furnish water to the canal. This lock and regulating weir will control the elevation of the summit level of the canal, which it is proposed to keep at the level of extreme low water in Lake Erie, viz, 568 feet above sea level.

THE WELLAND RIVER CROSSING.

From Rameys Bend to Welland the present canal will be enlarged by an extended excavation along the western bank. It crosses the Welland River by an aqueduct at Welland, as indicated in Fig. 1, but in the new structure it is proposed to raise the level of the river to that of the summit level of the canal by means of a dam across the river at Port Robinson. This dam will be provided with a large overflow and regulating weir, which will control the elevation of the summit level, allowing any surplus water to overflow into the old Welland River and pass out into the Niagara River at Chippawa, as at present. A sufficient quantity of water will be allowed to run constantly to keep the river clean.

The present aqueduct at Welland will be dredged out, as well as the bank between the canal and river. The river will be utilized between Welland and Port Robinson instead of the present canal, being somewhat more direct and entailing considerably less excavation. At Port Robinson a cut will be made through the present bank between the canal and the river, enabling vessels to reenter the canal prism. Between Port Robinson and Allanburg what is known as the ''Deep Cut,'' which has a maximum depth of 66 feet, will be enlarged by cutting a slice off the western bank.

In raising the Welland River above Welland some 1,600 acres of low land adjoining the river will be flooded. This land is not of any great value, as it is flooded every spring by the river overflow, limiting its agricultural value to pasturage only. The township of Wainfleet, adjoining the Welland River on the south side, consists principally of low-lying ground which drains into the Welland River, and to prevent damage to this land on account of the raising of the river it will be necessary to open up most of the ditches from the point of their present entrance to the river, to the intended high water mark.

Turning the Welland River into the canal will pollute the waters which are at present used by the towns of Welland, Thorold and Merritton and the city of St. Catharines for domestic purposes. This may necessitate the construction of extensive filtering plants, although this scheme is not looked upon with favor by those interested. An alternative scheme to lay a pipe line from Lake Erie to the reservoirs of the different municipalities, through which clean water would be continuously pumped, is under consideration and appears to be the most feasible scheme available.

Allanburg is now the junction of the present and old Welland Canals, and the water required for the latter, which is quite considerable, on account of the numerous power developments along it, is taken into the canal through a weir at this point.

In connection with the construction of the new canal, it is proposed to close the present old canal entirely between Allanburg and Marlatts Bridge, near Thorold, first building a new weir at the head of lock 25 of the present canal, to supply the above-mentioned water. A dam will then be thrown across the old canal at Allanburg, and the old bed of the canal between the dam and Marlatts Bridge will be utilized as a dumping ground in which to place the material removed from the above water in widening the deep cut. This will form a very convenient dumping ground, and the old canal will become more self-contained, as at present the entrance works are situated at an inconvenient distance from the remainder of the canal.

If it is desired to continue navigation on the old canal, entrance may be had to it through lock 25 of the present canal (a little south of the town of Thorold) when the new canal is completed by making a short cut through the bank separating the two waterways.

NEW LOCK NO. 7.

Between this point and Thorold will be located a pair of twin guard locks, just at the southerly limits of the town, and a short distance north of them will be located lock 7, the head of this lock being directly opposite the head of lock 24 on the present canal. Fig. 2 shows its general design. The portion of the present canal between locks 25 and 24, together with a pond of about 27 acres, formed by flooding the upper valley of the Ten Mile Creek, will be utilized as a regulating basin from which water to fill lock 7 will be drawn. This method of drawing water from a side pond, instead of directly from the canal above, avoids the formation of objectionable currents and surges in the canal and locks, and is the method adopted for filling all of the locks.

Below lock 7 will be a short reach of canal, with an adjacent pondage or regulating basin having a surface area of about 84 acres (see Fig. 1), and immediately below will be located twin locks, 6, 5, and 4 in flight. These three locks will overcome a descent of 139½ feet. One flight will be used for downbound vessels and the adjoining flight for upbound, a double flight being required to save long delays in the passage of vessels through the canal.

The main line of the G. T. R. between St. Catharines and Niagara Falls will cross over the foot of twin locks 4, by means of two short bascule lift bridges.

The Port Dalhousie-Welland branch of the G. T. R. is situated just where the new locks are to be built, and it will be necessary to divert it some distance to the west. The diverted line will bear the same relation to the new canal as the present line does to the present canal, following upon the west side of the locks, but remaining on the west side of the canal for some distance above the present lock 25, when it will cross the new canal by means of a bascule lift bridge.

From lock 4 the proposed waterway will run northwards, following in part the bed of the Ten Mile Creek until it crosses the present canal at the foot of lock 11, at an elevation of 382 feet above sea level. This is the level of the present canal at that point, and small vessels may, if desired, use the Port Dalhousie entrance, as at present, as far as lock 11. (See Fig. 1.)

Lock 3 will be located immediately north of the present canal, and at its head on the east side will be situated an equalizing basin or pondage with an area of 150 acres. Below lock 3 a heavy cut will be required through the village of Homer to a point where the bed of Ten Mile Creek is again reached, and below this point lock 2 will be built, as shown. It was difficult to find a location for this lock on account of the lack of rock for a foundation, but eventually a suitable foundation was found at this site. The canal at the head of lock 2 will be at an elevation of 335½ feet above sea level and will flood about 200 acres of land along Ten Mile Creek. Below lock 2 the canal will follow the bed of the creek to the lake, lock 1 being situated just below the Lake Road. The pond at the head of lock 1 will cover an area of 107 acres.

Some typical cross-sections of several locks are shown in Fig. 3.

THE ENTRANCE INTO LAKE ONTARIO.

The outer entrance piers in Lake Ontario will be placed about a mile and a half from shore, where the depth of water is 30 feet. A wide channel will be dredged from these piers to lock 1. The sides of this channel will be protected near the shore end by reinforced concrete cribs, with concrete superstructures, alongside which vessels may lie. This arrangement is illustrated in Fig. 1. From the shore line of the lake to the outer entrance piers an embankment about 500 feet wide will be formed on either side of the channel, from material excavated from the canal between the lake and Thorold. For the purpose of conveying this material from the different contracts to the lake, the Department of Railways and Canals will build a double track railway along the west side of the canal from the foot of the flight locks near Merritton to the lake, and temporary trestles will be built out in the lake on either side of the harbor, from which to start the dumps. The railway will also be utilized to haul crushed stone from the site of the flight locks to locks 1, 2 and 3, for making concrete. The contractor for the rock excavation from the site of the flight locks will, under his contract, be obliged to crush a sufficient quantity of the good rock taken from

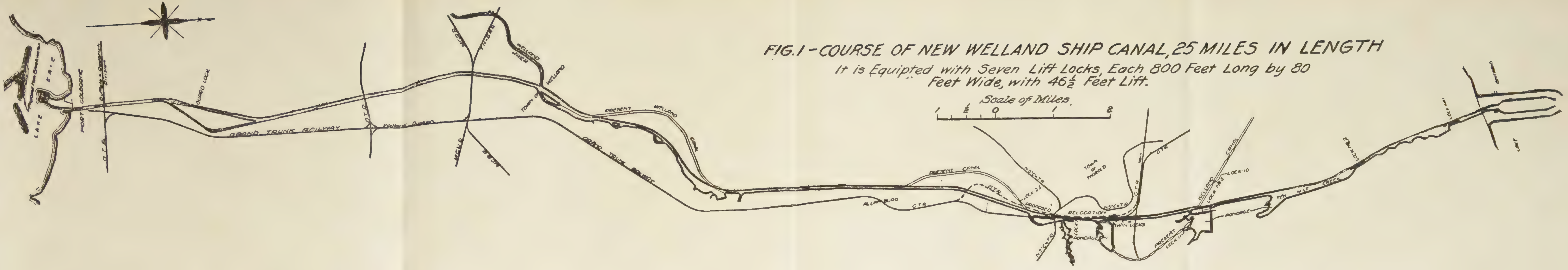
Scale of Miles
1 ½ 0 1 2
LAKE ERIE
PORT COLBORNE
GUARD LOCK
GRAND TRUNK RAILWAY
WELLAND RIVER
TOWN OF WELLAND
PRESENT WELLAND CANAL
PRESENT CANAL
TOWN OF THOROLD
ALLANBURG
G.T.R.
PROPOSED
RELOCATION
TWIN LOCKS
PONDAGE
PRESENT LOCK 11
WELLAND CANAL
LOCK 10
TEN MILE CREEK
LOCK No. 2
LOCK No. 1
LAKE

FIG. 1 - COURSE OF NEW WELLAND SHIP CANAL, 25 MILES IN LENGTH

It is Equipped with Seven Lift Locks, Each 800 Feet Long by 80 Feet Wide, with 46½ Feet Lift.

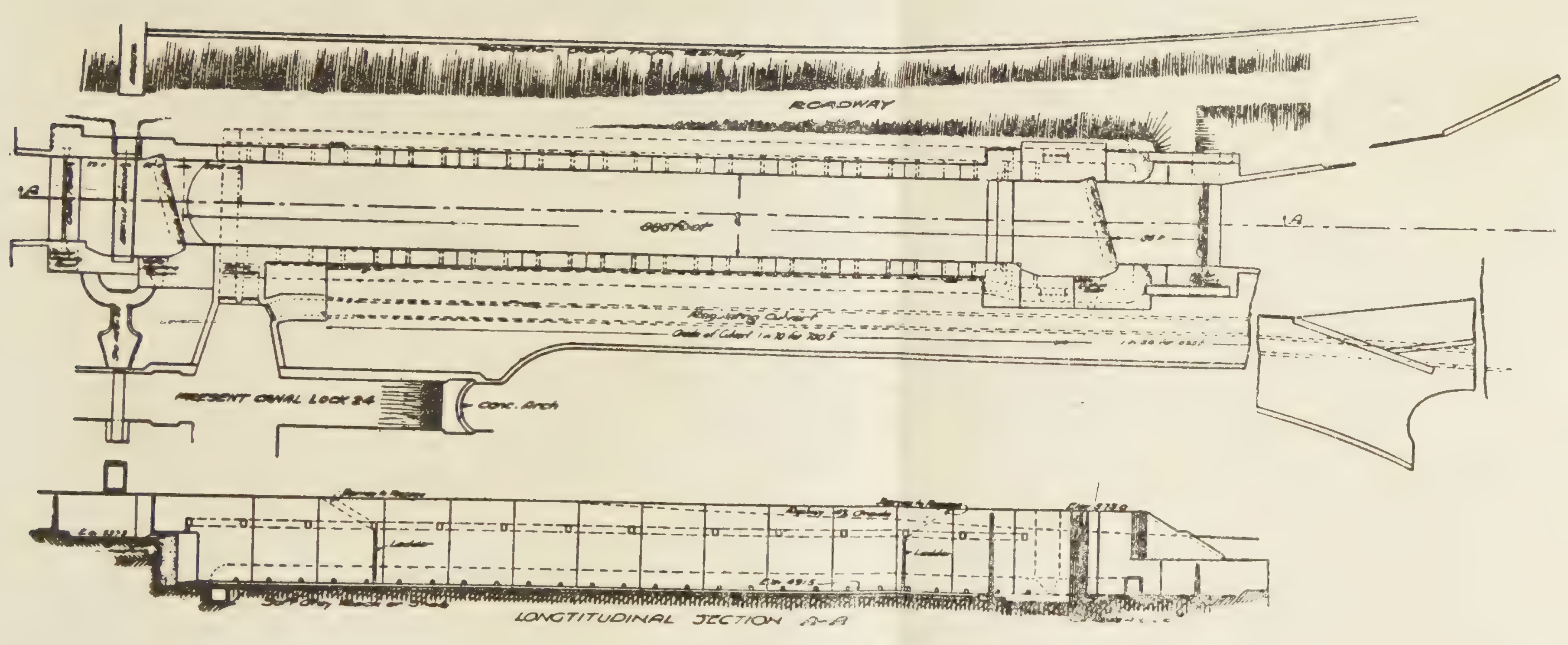
ROADWAY
Regulating Culvert
PRESENT CANAL LOCK 26
Conc. Arch
A
A
LONGITUDINAL SECTION A-A

FIG. 2 - GENERAL ARRANGEMENT OF LOCK NO. 7
WELLAND SHIP CANAL

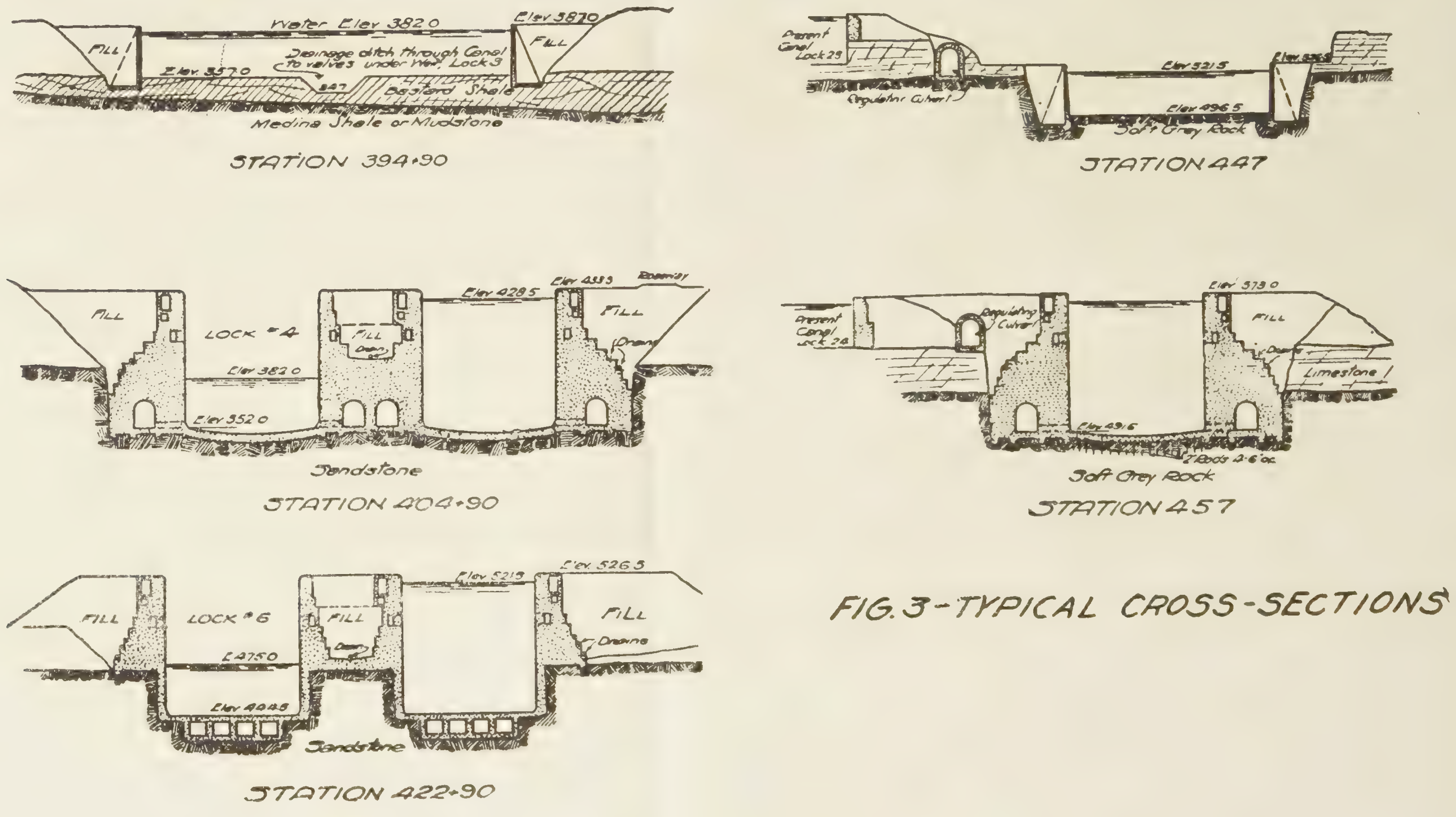
Water Elev. 382.0
Elev. 387.0
FILL
FILL
Elev. 357.0
Drainage ditch through Canal to valves under Wier, Lock 3
Medina Shale or Mudstone
STATION 394+90
Present Canal Lock 25
Regulating Culvert
Elev. 521.5
Elev. 496.5
Soft Grey Rock
STATION 447
FILL
LOCK #4
Elev. 428.5
Elev. 433.3
Roadway
FILL
Elev. 382.0
Elev. 352.0
Drains
Sandstone
STATION 404+90
Present Canal Lock 26
Regulating Culvert
Elev. 573.0
FILL
Limestone
Elev. 491.5
Soft Grey Rock
STATION 457
FILL
LOCK #6
FILL
Elev. 521.9
Elev. 526.5
FILL
Drains
Elev. 475.0
Elev. 404.5
Sandstone
STATION 422+90

FIG. 3 - TYPICAL CROSS-SECTIONS

his excavation to supply all the crushed stone required for making all the concrete for the different locks and structures.

The construction of the new canal is under the direction of the Department of Railways and Canals. It will cost approximately fifty million dollars. The engineer in charge of the entire construction is Mr. J. L. Weller, M. Can. Soc. C. E.

The contract for the first section of the work, a length of about 3 miles, including lock 1, and the pier works at the Lake Ontario entrance, was awarded early in July to the Dominion Dredging Company, Limited, Ottawa, the contract price being about $3,500,000. Other sections are following closely, and contracts for them will be awarded before the close of August.

On What Basis Should Recommendation for a Waterway Improvement be Made?

By

Maj. GEORGE P. HOWELL
Corps of Engineers; Member American Society Civil Engineers

In an article in the July-September, 1910, issue of PROFESSIONAL MEMOIRS, by Lieut. Col. George A. Zinn, Corps of Engineers, on "The Advisability of a Waterway Improvement," the author propounded the question: "Is it possible to devise a method or system to be followed in determining the value or importance of any proposed improvement, or to enumerate all the elements which bear upon the advisability of a waterway improvement, so that an opinion formed from them will be a necessary conclusion rather than a random guess?" and, in elaborating his subject by specific examples, it was pointed out that in a number of cases a main factor in the problem was the regulation of railroad freight rates. It is only too evident that Congress frequently orders examinations of interior rivers and streams because the people living near these streams wish lower railroad rates; at times this is the only reason advanced. Some of the most extensive and expensive schemes to which we are now committed are based upon that idea. The district officer recommended the improvement of the Trinity and Brazos rivers in Texas because water competition appeared to be the only practicable way of reducing and controlling rates. As reported to Congress, it was proposed to expend $4,550,000 on the Trinity River and $2,915,000 on the Brazos River.

It has not been taken into consideration that when rates are lowered in one place, they must be raised elsewhere; and that the same amount of money will be lost in the raising as is saved in the lowering. I believe, however, that the time has come to revise our ideas on rate regulation. When commodities can be carried cheaper by water than by rail, the railroads lower their rates on such commodities to meet the competition. This lowering is gradually extended to all commodities and classes of freight, so that seaports and places on navigated streams receive the ''water rate,'' which is lower than the railroad rate to interior points. The anomaly consequently exists of freight destined for an inland town passing through such town en route to a ''water rate'' port and being returned thereto by local freight. This is manifestly unfair to the citizens of the inland town. The railroads must have a certain amount of revenue; there is an equitable rate, based upon the service rendered, which would give the revenue and bear equally upon all the patrons of the railroad. If a city on a river bank has rates lower than this, freight is carried to this place at a loss to the railroads, and the interior points must make up the deficiency. The railroad is a ''common carrier'' and rebates are sternly forbidden. The United States Government through the Inter-State Commerce Commission, does not permit discrimination between shippers in the same place; the little man gets just as good a rate as the big fellow; but it allows discrimination between localities. The railroad should be just as fair and equitable to all its patrons living along its line as it is to those living in one locality.

The Government, in giving heed to this demand for ''water rate,'' unduly favors one community at the expense of another. With lower rates, wholesale jobbing establishments are established which undersell the merchants of the unfortunate towns in territory that belongs to the latter. Augusta, Ga., undersells Columbia, S. C., in places visible from the latter's skyscrapers. To carry this policy to its ultimate logical conclusion, we would have to improve every little rivulet in the country, as has been forcibly brought home to me lately. Wilmington, the chief seaport of North Carolina, naturally has the ''water rate;'' Fayetteville, 115 miles above Wilmington, on the Cape Fear River, wanted the same ''good thing'' and has succeeded in getting through a project for the canalization of the river. Thirty-five miles from Fayetteville in the adjoining county is Lumberton, 67 miles from Wilmington by railroad. Lumberton discovered that Fayetteville was underselling it in adjacent country and that the cause was the improvement of the Cape Fear. Lumberton furthermore discovered that it too was situated on a river, and straightway asked to have it improved. They were perfectly frank about it; they wanted to have the same rates as Fayetteville. If the Lumber River had been improved on these grounds, every creek, tributary to it, that boasted a settlement, logically could ask improvement too.

Rates should therefore be fixed or regulated by the Inter-State Commerce Commission, or the various State commissions, according to mileage; and railroads should not be permitted to lower them on account of water competition. It is unfair and uneconomical for the Government to spend the taxpayers' money in regulating rates by snag pulling, dredging, and canalization, when the same thing can be done much more quickly and more equitably by a stroke of the pen. The railroads are beginning to see that this is the proper procedure. I have lately read in the *Engineering and Railroad Review* an article by a railroad man on rate regulation, in which he states that rates should be on a mileage basis, and that a railroad should not be allowed to lower the rate any more than to raise it. Members of Congress—who order these improvements, and as such are really our employers—are beginning to take a different view of river improvement. Senator Burton, in debating the last river and harbor bill, said:

> It is said that the reason for improving these streams is very largely the regulation of freight rates. I maintain that that is an erroneous policy. Waterways and railways alike are agencies for transportation. The question is, Which is the better way? The railways, built by private capital, cost money; the improvement of rivers and harbors cost money. In either case the amount expended is a charge upon the resources of the country.
>
> The better way to regulate freight rates is by legislation, by the appointment of commissions, by the exercise of those functions which the different departments of the Government possess. Also, if the improvement of a waterway lowers freight rates in that locality, is it quite just to that greater area which is removed from that waterway? Whatever decrease must be made in charges on railways paralleling the river or waterway must practically be made up by increased charges where waterway competition does not exist.

The reason why rate regulation has been advanced as a reason for river improvement is, as stated by the district engineer in the report on the Trinity River, already alluded to, that there has been no way of determining what is a proper rate, "the railways establishing in the litigation that any reduction was confiscatory, the original and accrued cost of the railways, as represented by their stock and indebtedness, and not their present value, apparently being the basis from which is computed the reasonable profit of which they can not legally be deprived by National or State railway commissions." At the last session of Congress, however, an act was passed directing the Inter-State Commerce

Commission to make a valuation of railroads, with the understanding that the rates to be charged would be fixed on the basis of valuations. It will take some years to make this valuation; but Congress has definitely spoken and we know what its attitude is regarding rate making. The officers of the Corps engaged on river and harbor work can assist Congress—and can even bring about this reform as long as Congress adheres to its present policy of adopting only such projects as are recommended by us—by basing the opinion as to the advisability of an improvement solely upon the grounds of its *success as a freight carrier, and not as a rate regulator.*

Gen. Charles Walker Raymond

Class of 1865. (See frontispiece.)

BY

Brig. Gen. OSWALD H. ERNST
*Corps of Engineers; Member American Society
Civil Engineers*

Born at Hartford, Conn., January 14, 1842.
Died at Washington, D. C., May 3, 1913.

Graduating at the head of his class in 1865, Raymond was appointed to the Corps of Engineers with the rank of First Lieutenant, skipping the grade of Second Lieutenant entirely. This sudden advancement, which he owed to fortune, was typical of the rapid strides he was destined to make in his profession and which he was to owe to himself. He immediately took his place in the front rank of officers of his grade, and never lost it, his mind being developed and strengthened as his age, rank, and responsibilities increased.

His first independent duty was to examine the Yukon River, from its mouth to Fort Yukon, in Alaska in 1869. The country had been acquired from Russia a few years before, and almost nothing was known about its interior. The Hudson Bay Company had a post at Fort Yukon, and it was uncertain whether the post was on the American or the British side of the boundary. To obtain a knowledge of the Yukon River was of much importance from a military as well as an economic standpoint. The selection of Raymond to make the examination was fully justified by the result. A small steamer belonging to a fur company was to make a special trip up the river as far as Fort Yukon, and Raymond, accompanied by one assistant and provided with the necessary field instruments, took passage on her. When they arrived at Fort Yukon, those in charge of the steamer decided to shorten their stay there and to return to the mouth of the river much sooner than had been expected. Raymond had not completed the astronomical observations necessary to determine the geographical position of the post, and declined to leave until that work was finished.

He was left there to find his way out as best he could. He afterwards ascertained that the post was on American territory, and ordered its removal, and then he and his assistant had an adventurous journey down the river, in the course of which they nearly lost their lives. In ascending the river he made a map of it, the first one ever made. He displayed great energy, skill, and tenacity of purpose throughout the expedition, and collected a large amount of information which his rare literary capacity enabled him to lay before his superiors in complete and lucid form.

In 1874 he was selected to command a much larger and more important distant expedition, that sent by the United States Government to Northern Tasmania to observe the transit of Venus. The result was as satisfactory as before.

The limits of this paper will not permit a detailed statement of Raymond's varied services. They will be found in outline in ''Cullom's Biographical Register.'' The foregoing instances are given as showing the estimation in which he was held by his superiors in the early part of his career. He served upon river and harbor improvement, coast defenses, and surveys upon the Pacific Coast, the New England Coast, and the Gulf Coast; also as Commissioner of the District of Columbia; his standing in his Corps increased with every added year until, in 1890, he was assigned to duty at Philadelphia, his mental powers fully matured, and his reputation thoroughly established.

He remained on duty at Philadelphia until 1902, and during these twelve years did much of the most important work of his life. There his courage and originality as an engineer were conspicuously displayed in the completion of the Delaware Breakwater according to novel designs and methods of his own. Besides the local works of river and harbor improvement and of fortification of which he had charge, he was called upon to serve upon many of the most important Boards of Engineers convened by the War Department during that period, of which there were more than a dozen to which he was detailed. Perhaps the most important of them all was the Board convened to report upon the various routes for a deep waterway from the Great Lakes to the Atlantic Ocean.

This Board made elaborate studies of the different routes, and original investigations of various matters, including locks of unprecedented lift and dimensions, consuming several years time in the work. Its report is an engineering classic. Boards to report as to the maximum span practicable for suspension bridges, and as to the span practicable for a bridge over the Hudson River at New York, were some of those to which Raymond was called upon on account of his exceptional mathematical ability. The report of the former contained an analytical discussion of the Theory of Suspension Bridges, mainly prepared by him, which was subsequently used in Europe as a text-book of instruction.

His reputation extended far beyond the limits of the Engineer Corps and the War Department. In 1902 he became a member of the Council of the Permanent Commission of Navigation Congresses, having its headquarters at Brussels, Belgium, and in 1903 was made chairman of the American Section, a position which he held until his death. In 1902 also he was called by A. J. Cassatt, the great president of the Pennsylvania Railroad, to be chairman of the Board of Engineers appointed by that road to supervise the construction of its tunnel extension into New York. This Board had for its members some of the most eminent civil engineers in the United States. In the magnificent new terminal of the Pennsylvania Railroad in New York is a marble tablet, upon which appear the names of the men most prominent in bringing that great enterprise to a successful completion. Among them is the name of Gen. Charles W. Raymond. No man could ask for a finer monument.

In 1904, at his own request, he was retired from active service. While a Cadet on furlough in 1863, he had served by authority of the Secretary of War as aide-de-camp to Major-General D. N. Couch, commanding the Department of the Susquehanna, during the Gettysburg campaign in June and July, 1863. For this service he received an additional grade upon retirement, and became a brigadier-general upon the retired list. He continued, however, to occupy himself with the Pennsylvania tunnels and other civil engineering matters.

He was a member of the American Society of Civil Engineers, and of the Washington Academy of Sciences.

For some years before his death he had much trouble with his eyesight and finally, in 1912, became totally blind. He had been in the hands of Dr. Wilmer, the celebrated oculist of Washington, who expressed the opinion that the sight could be at least partially restored by an operation. Early in the autumn of 1912, General Raymond went to Washington to have the operation performed, but Dr. Wilmer found that his physical condition otherwise was such that the operation could not be risked. It was necessary that other ailments should be attacked first, and other specialists were called in. Then followed many months of great physical suffering, aggravated by total blindness, which were endured with a fortitude, an equanimity and a cheerfulness which were the wonder of all observers. General Raymond had many friends in Washington who made it a point to visit him frequently. If at first they were actuated by a feeling of compassion, they soon found that they were receiving as much pleasure as they gave. His mind was as clear as it ever was. He was fully posted in the news of the day and with the latest books, all of which were read to him by his devoted wife. He was full of interesting reminiscences, and his conversational powers were of a high order. He never uttered a word of complaint. If allusion was made to his condition, he spoke hopefully of his recovery, until near the end when there could be no hope, and then there was no murmur. Men who had known him half a century gazed at him in amazement, feeling that they had never before fully appreciated the serene heroism of his character. They uttered to themselves a silent prayer that if ever such trials should come upon them they would be able to meet them as he did.

Concrete and Metal Fences*

BY

Mr. FRANK D. HOLBROOK

Assistant Engineer; Member American Society
of Civil Engineers

The fence shown in the accompanying illustrations was fabricated by the day-labor force at Dam No. 15, Ohio River. A total of about 1 mile of fence was built, and it has been used for inclosing the Government property at Dams Nos. 14, 15, and 18. The following cost data has been taken from the record at Dam No. 15.

Angle and gate posts, each	$3.35
Ordinary posts, each	1.23
Fabricating panels, each	2.78
Painting panels (three coats), each	.74

Above prices include cost of forms for posts and all materials and labor.

Setting fence (295 panels at Dam No. 15), each	$0.91

Panels are 9 feet 11 inches center to center of posts, large gate has 10 feet clear opening and small gates 4 feet.

Cost of about 3,000 linear feet of fence erected at Dam No. 15, $0.5707 per linear foot in place.

The cost of setting up the fence will vary with the nature of the soil. At Dam No. 15, for about one-half the fence erected, the soil was a heavy clay with much shale embedded. This made the digging of post holes rather expensive.

All posts are 1-2-4 concrete, mortar faced, beveled corners and reinforced with ¼-inch steel rods. Ordinary posts are 5 by 8 inches at the base, tapering to 5 inches square at the top, with one rod in each corner. They are 7 feet long and set 2 feet 6 inches in the ground. Angle and gate posts are 10 inches square for their whole length, with a 2 inch projection 2½ inches below the top and reinforced with eight rods, four at the corners and four in the faces.

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*With cost data by Lieut. Jarvis J. Bain, Corps of Engineers.

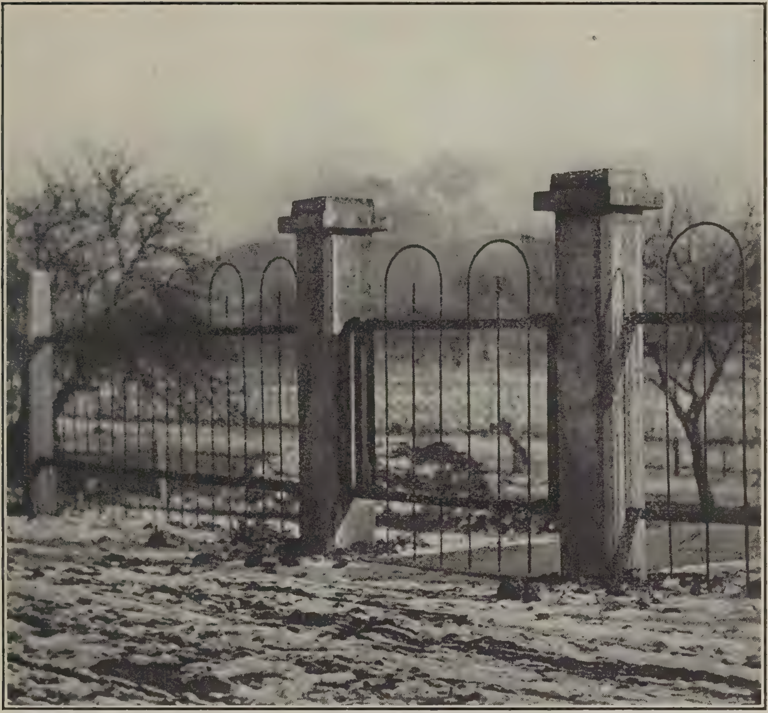

Fig. 1. Fence at Dam No. 15, Ohio River; reinforced-concrete posts, steel panels.

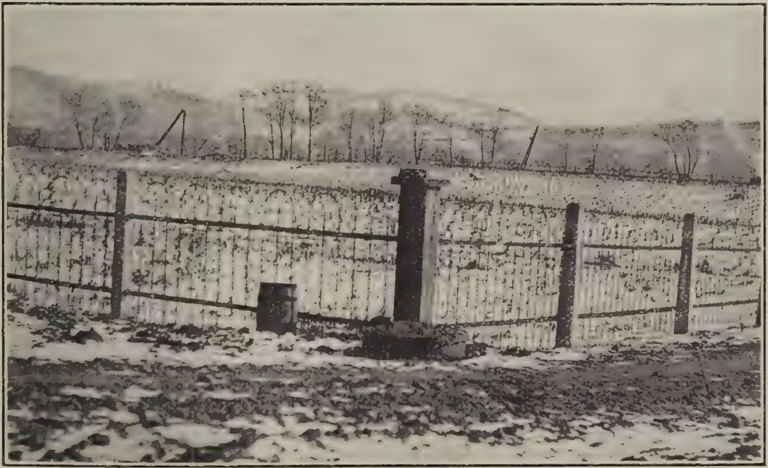

Fig. 2. Fence at Dam No. 15, Ohio River; reinforced-concrete posts, steel panels.

They are 7 feet 6 inches long, 2 feet 6 inches in the ground and project 6 inches above ordinary posts. Two lugs, 2 inches by 3/8 inch, running through the posts, carry the panels. These lugs extend a short distance on two sides of the post, and have the 2 inch dimension horizontal.

The panels and gates are made up of 3-inch 5-pound channels with 3/8 inch round pickets. The pickets are caulked tight in the channels on the under side. The lugs are bent after the posts are seasoned to suit the slope of the fence. Panels secured to the posts by 5/8-inch bolts extending vertically through channel and lug.

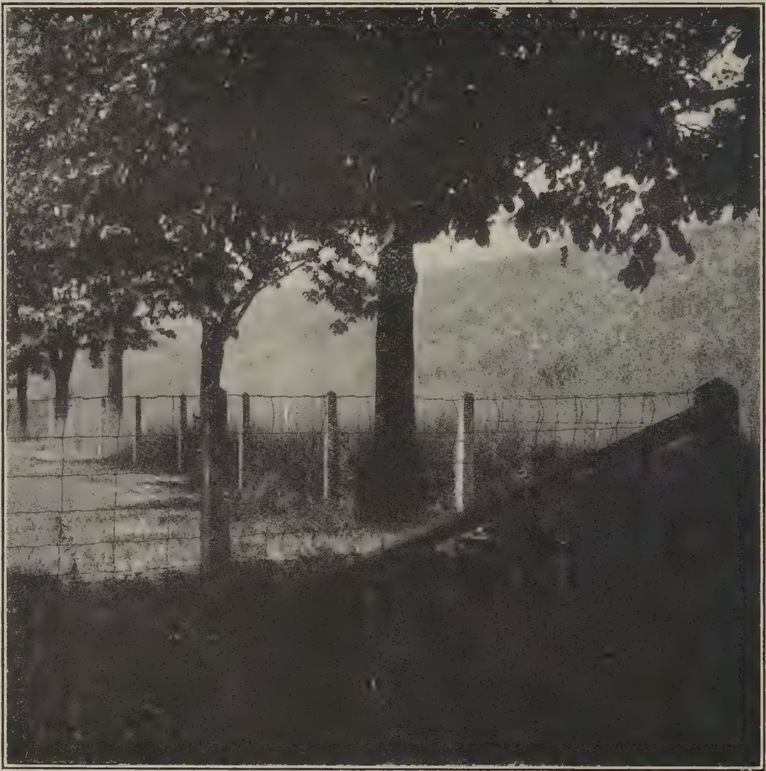

Fig. 3. Galvanized-wire fence with concrete posts, Georgetown Reservoir, Washington Aqueduct.

At the site of most of the Ohio River dams the property is overflowed in extreme floods. The panels are then simply removed and laid flat on the ground so as not to obstruct the passage of drift and débris with which the river is filled at such times. After the floods have passed, the panels are brushed off and replaced.

Through some of the lowest ground where the current was very strong during floods the posts were made 7 feet 6 inches long and set 3 feet in the ground, the hole which was dug for the post being filled with poor concrete to within about 10 inches of the surface.

If the posts are brushed over with the following mixture, much will be added to the appearance of the fence:

20 parts cement, 20 parts very fine sand, 1 part yellow coloring matter. Add sufficient water to make a thin grout, keep well stirred and apply with a small whitewash brush. At Dam No. 15 this cost six cents per post.

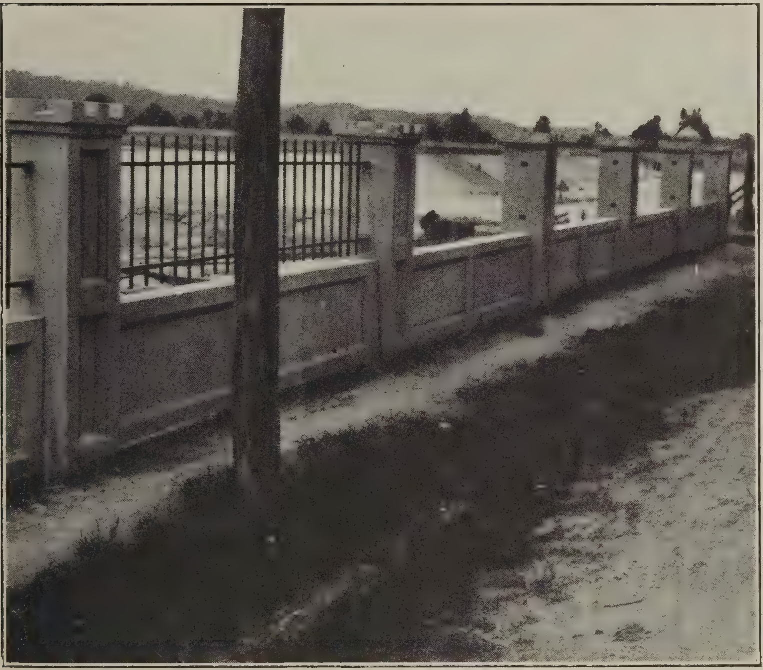

Fig. 4. Concrete and steel fence at Georgetown Reservoir, Washington Aqueduct.

The following cost data and the accompanying illustrations pertain to the three types of concrete fences which have been built, and which are being built, on the lands of the Washington Aqueduct. These fences were designed by Captain Hannum, Corps of Engineers, U. S. A.

Wire Fence with Concrete Posts at Georgetown Reservoir.

Material for posts	$70.30
Labor, making posts	127.50
Labor, digging post holes	22.75
Labor setting posts	79.60
Labor, placing wire on posts	62.75
Wire fence, 330 rods or 5,450 feet	214.00
Total	$576.90
Length of fence, in linear feet	5,339
Number of fence posts	444
Cost, per linear foot	$0.108
Cost, per post	.445

Concrete and Steel Fence at Georgetown Reservoir.

Steel fence and gates	$1,092.32
Paint	105.00
Cement	748.44
Sand	22.54
Gravel	51.75
Stone dust	133.00
Granolithic	423.00
Lumber for forms	74.82
Brass letters	28.70
Wire brushes	4.56
Labor, surveying	72.53
Excavating and placing foundation	220.67
Building forms	73.18
Mixing and placing concrete	1,442.18
Removing forms and scrubbing concrete	341.17
Hauling materials	44.80
Erecting steel fence and painting	121.88
Grading	213.24
Superintendence and office work	139.06
Main office charges	145.42
Total	$5,498.26
Number of linear feet of fence	2,158
Cost, per linear foot	$2.55

Guard Fence, Georgetown Reservoir, Culvert No. 26.

Cement	$42.57
Sand	21.06
Gravel	36.96
Lumber for forms	32.00
Steel for reinforcing	16.48
Labor	237.74
Total	$386.81
Total length of fence, in feet	380
Cost per foot	$1.02

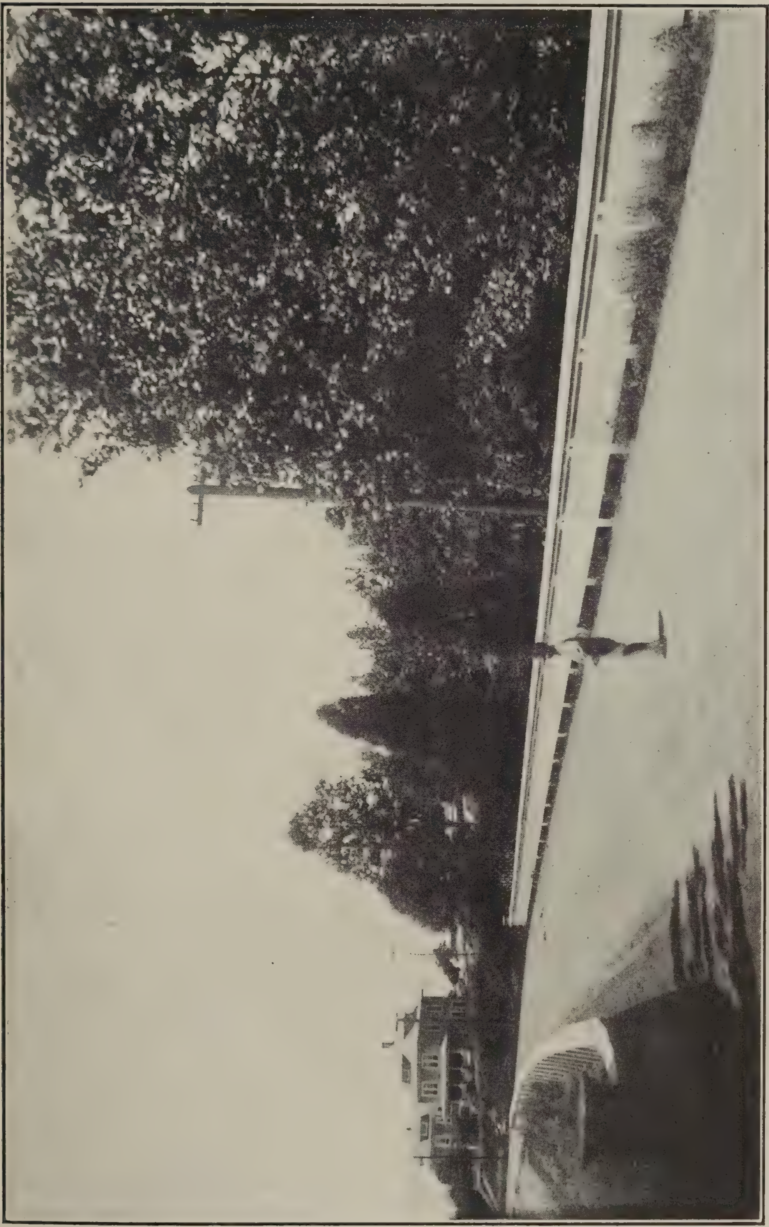

Fig. 5. Concrete guard fence, Conduit Road; Washington Aqueduct.

Cost of Government Dredging v. Contract Dredging

BY

Lieut. Col. HARRY TAYLOR
Corps of Engineers; Member American Society Civil Engineers

An examination of the Annual Report of the Chief of Engineers for the fiscal year ending June 30, 1913, shows clearly the difference in the cost of dredging with Government dredges and the cost by contract as follows:

a. Government dredges excavated during the year a total of 52,564,497 cubic yards at a cost of $3,786,407.45, or an average rate of $.072 per cubic yard. This amount of material was divided between the different classes of Government dredges as follows: Hydraulic pipe-line dredges, 21,351,780 cubic yards at a cost of $1,363,534.68 or at a rate of $.06386 per cubic yard; by seagoing dredges 27,502,996 cubic yards at a cost of $1,687,707.78,or at a rate of $.06136 per cubic yard; by dipper and bucket dredges, 3,709,721 cubic yards, at a cost of $735,164.99, or at a rate of $.1981 per cubic yard.

b. Dredging contracts completed during the year or in force at the end of the year, included a total excavation of 181,873,125 cubic yards at a cost of $26,213,962.70, or at an average rate of $.1441 per cubic yard. This excavation was divided among different classes of dredges as follows: Hydraulic pipe-line dredges, 101,518,980 cubic yards at a cost of $10,311,930.39, or at a rate of $.10157 per cubic yard; by dipper and bucket dredges, 80,354,145 cubic yards, at a cost of $15,902,032.31, or at a rate of $.1979 per cubic yard.

The above shows that during the fiscal year 1913, the hydraulic dredging done by contract cost the United States 62 per cent more than that done by Government hydraulic dredges, including seagoing dredges, and that the cost of other classes of dredging by Government plant and by contract was practically the same. Considering the total excavation, however, the cost per cubic yard for contract dredging was almost exactly double that done by Government dredges.

In the cost of dredging by Government plant there is included all expenses for operation, ordinary and extraordinary repairs, surveys, and such office expenses as are chargeable to dredging operations, while the cost of the contract dredging is the contract cost only, and does not include the cost of Government inspection, surveys, office expenses, etc., that are charged against the Government plant.

It should be further noted that the dredging done by the United States by dipper and bucket dredges was a relatively small amount and was nearly wholly confined to the Tennessee and Ohio rivers where the work was usually in small quantities and widely distributed, thereby making the cost per yard greater than under ordinary circumstances.

Further, the costs of the dredging plants in use by the Government are as follows:

	No. vessels.	Cost.
Seagoing dredges	22	$6,007,575.56
Hydraulic dredges, including necessary plant of pontons, barges, and tugboats	54	4,562,325.39
Dipper dredges, including tugs, scows, etc.	40	1,493,440.74
Bucket dredges, including tugs, scows, etc.	22	520,221.85
Total		$12,583,563.54

It will be seen by this table that the difference in cost of removing the 181,873,125 cubic yards excavated under contract and what it would have cost by Government plant would more than pay for all the plant owned by the United States.

It is interesting to note that the amount of material covered by the foregoing figures is 234,437,621 cubic yards, or an amount equal to a prism 48 feet wide and 9 feet deep extending from the Atlantic Ocean at Norfolk, Va., to the Pacific Ocean at San Francisco, Cal., at a total cost of $30,000,370.15.

Notes on River and Harbor Works

DREDGING AT PINOLE SHOAL, SAN PABLO BAY, CALIFORNIA.

The method of supporting the wooden stave pipe line on the piles is clearly shown in illustration. The piles are spaced about 16 feet centers, a ¼-inch spike is driven into the pile near the top and the end of a ⅝-inch diameter wire rope is fastened to this spike, the rope is then passed around the pipe and the other end of the same fastened to the spike. The wire loops are passed around the pipe and piles alternately right and left.

This method of hanging the pipe line has proven most satisfactory and is very economical with regard to labor and material.

San Pablo Bay is 12 miles long by 6 miles wide and is about 10 miles northeast of San Francisco Harbor. Before improvement there was a shoal with a least depth of 19 feet at mean low water, lying across the path of vessels going to and from the Sacramento and San Joaquin rivers and Mare Island Navy Yard. For deeper draft vessels navigation was possible only at the highest stages of the tide. Improvement is needed to permit naval vessels to reach Mare Island Navy Yard at all stages of the tide. It is not required by the present commerce and has no effect on freight rates.

The existing project, adopted February 27, 1911, provides for dredging the channel in San Pablo Bay to a width of 500 feet and a depth of 30 feet, and for a dredge for maintenance. (See House Doc. No. 1103, 60th Congress, 2d session, which contains maps.) The total estimated cost of the War Department part of the project is $760,000, with $100,000 annually for maintenance.

The work is being done under continuing contract by the San Francisco Bridge Company at 18⅞ cents per cubic yard. The total quantity to be dredged under this contract is 2,506,000 cubic yards.

The channel when completed will be maintained by a Government dredge, which is now under construction.

LOCK GATES FOR THE OHIO RIVER LOCKS.

The Ohio River Locks are uniformly 600 feet long by 110 feet wide, with a lift of from 6 to 9 feet, except at the Louisville and Portland Canal where the maximum lift of new Lock No. 41 will be 40 feet. The gates of this lock will be of the mitering type.

Rolling gates, up to the present time, have been used on all the Ohio River locks except No. 41. This type of gate was believed to be the best suited for these conditions of low lift and extreme width of chamber. The weight of the gate is borne on standard car wheels. In opening, the gate is rolled back into the recess, the construction of which can be readily understood from the illustration which is shown on page 247. In the upper river, to which section the canalization improvement has thus far been principally confined, the rolling gates have been in successful operation for several years.

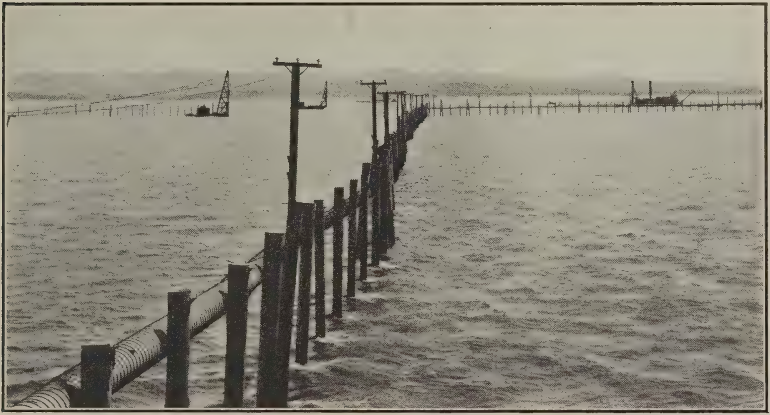

Fig. 1. Dredging at Pinole Shoal, San Pablo Bay, California. Looking south from Relay Station on Pipe Line No. 2.

Recently, however, upon recommendation of the Ohio River Board, the Chief of Engineers has approved the use of miter gates for all locks not yet under construction. This change was made as the result of experience which has been particularly unfavorable to the rolling gate at Lock No. 37, a short distance below Cincinnati where after each high water the gate recesses have been found almost completely filled with a deposit of mud and sand. The gates could not be closed until this deposit was removed, an operation which with all available facilities has required from four to five weeks steady work, day and night. Every effort has been made to lessen the deposit. During the last flood one of the gates was fully opened and the recess tightly bulkheaded; the other gate was left sticking part way into the lock chamber in the hope of creating a current in the recess. In both cases the recesses were found practically filled with deposit up to the cover plates.

In the upper part of the Ohio the coarse gravel bed of the stream and the shorter duration of the floods are more favorable to the rolling gate, but in the lower river the bed and banks are so soft and shifting and the duration of the floods so great that the adoption of miter gates is clearly necessary to avoid the trouble experienced at Lock No. 37.

In point of cost of materials there appears to be some little advantage in favor of the rolling gate, but in time and ease of construction and probably in ultimate cost the advantage lies with the miter gates.

CASCADES CANAL, COLUMBIA RIVER, OREGON.

The Cascades of the Columbia River are located 150 miles above the mouth at the head of a narrow gorge, some 4½ miles in length, through which the river crosses the Cascade Mountain Range. In the first 2,500 feet of this gorge, known as the Cascades, there is a fall of 24 feet at low water, and below this are rapids which extend throughout its length. The project for improving this locality, adopted in 1877 and practically completed in 1896, provided for the construction of a canal for the passage of the Cascades and for the improvement of the rapids below to secure a low-water channel depth of 8 feet. This canal is 3,000 feet long and at its lower end is provided with a lock 521 feet long between hollow quoins, 90 feet wide, and having a lift of 24 feet.

Lock Gates.

The gates are of steel, of the horizontally framed circular arched type with single skin and swing freely on the pivots without the aid of rollers or flotation chambers. They were designed by Col. Edward Burr (then Lieutenant) and when constructed were of unprecedented size, and in service are said to have given excellent satisfaction.

Culvert Valves.

These are of the butterfly type, 9 feet 10½ inches wide by 10 feet 4 inches high and are made of structural steel. Although extensive repairs have been necessary from time to time, it is rather surprising to find that this size and type of valve has operated successfully under a head as great as 24 feet. In more recent construction cylindrical or stoney gate valves are generally used where the head is greater than 15 to 18 feet.

The operating machinery consists of hydraulic cylinders with a working pressure of about 200 pounds per square inch, supplied by gravity through a 10-inch pipe leading from a nearby mountain stream having an elevation nearly 500 feet above the lock. The valve engine is a cylinder 15¼ inches in diameter by 6-foot stroke, placed in a recess on top of the wall and connected through a well to the valve.

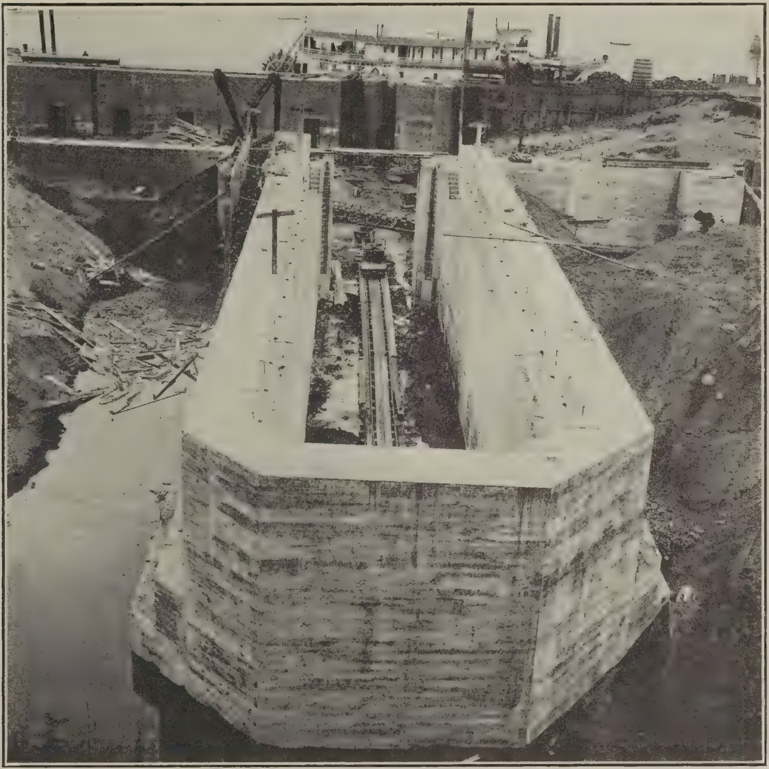

Fig. 2. Gate recess, Ohio River Locks, during construction.

The gate-maneuvering engines are similar cylinders 18 inches in diameter by 13 feet 6 inches stroke, arranged to operate the gates by wire ropes attached to the gates near the miter end. Each engine opens the gate on its own side and closes the opposite leaf. Both engines of a pair must therefore be operated simultaneously. In later designs the gate engine operates the gate directly by means of an operating strut hinged to the top girder at a point about one-fourth the length of the leaf from the quoin post.

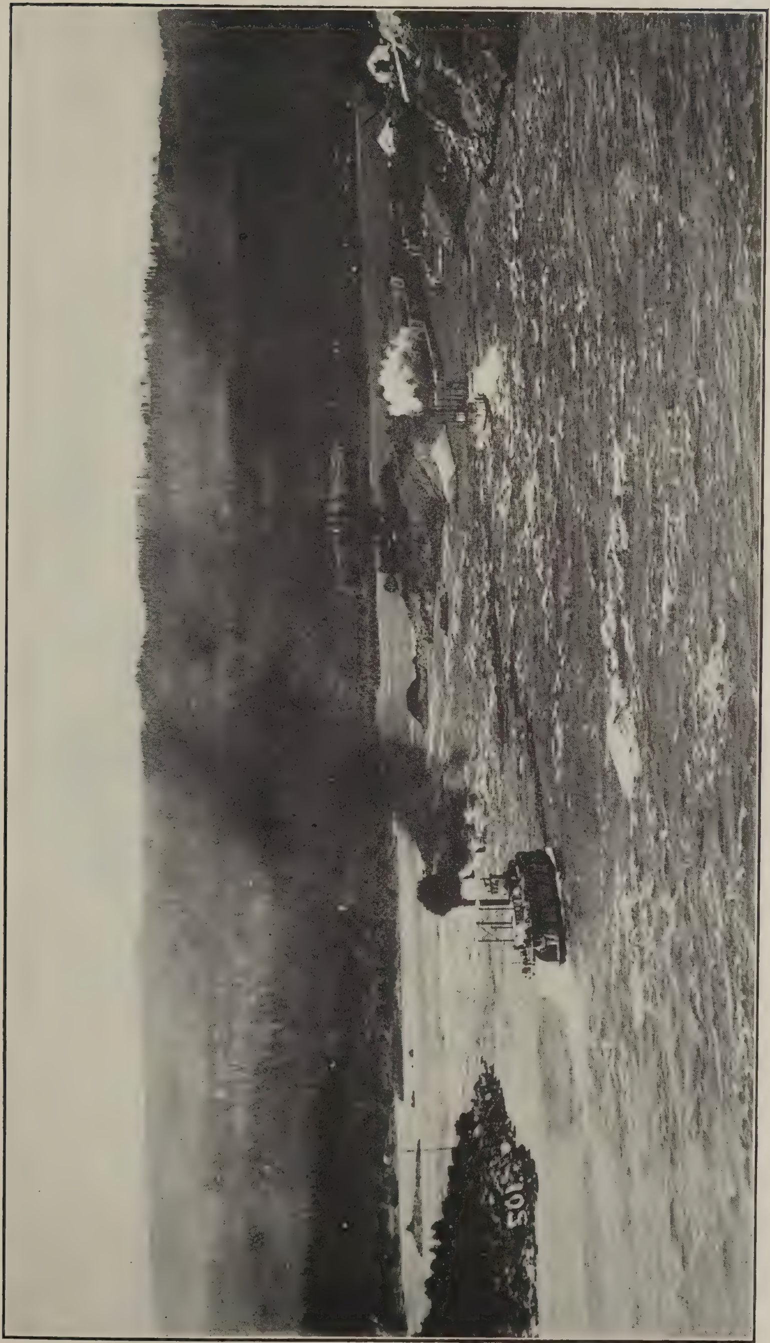

Fig. 3. Cascades Canal and Locks, Columbia River, Oregon. Looking upstream.

Maximum Flood Discharges

STAFF ARTICLE

It is sometimes important to obtain the maximum discharge or maximum gage height which a given stream is liable to have. This has assumed increased importance lately because of the disastrous floods of the past year. Even in parts of the country where very serious floods have not yet occurred people have begun to realize that they may have such a visitation. Some rivers like the Mississippi, because of their extreme importance, have been the object of special study and there is much information on hand concerning them; but for many streams the engineer is at a loss how to estimate for the highest future flood. The common method is to take the greatest gage height on record and assume that there are to be none higher in the future, a method which leads to bad results unless the records include an extraordinary flood, which they may not do even if they extend over a considerable period. It is also dangerous if the unusual flood occurred some time since and conditions in the valley have changed in such a way as to cause higher water for the same discharge per second.

Another method of getting the maximum discharge is to look in encyclopedias, hand-books, text-books, etc., for information, and one is there met with all kinds of methods for getting the discharge. Some books will give the discharge in cubic feet per second per square mile for various kinds of country from flat to very mountainous; some of them give the discharge as a function of the area, followed by a note saying that this formula applies to Northern India or Southern Italy or some other place which the engineer is not interested in; and some books give the run-off from various classes of soils in terms of the rainfall. Then the engineer is as much at sea as ever, because the study of the rainfall is a complete problem in itself and the flood may come from melting ice and snow or an ice gorge. The different results from the encyclopedia method do not seem to agree and the general result is more uncertainty.

Two studies on this subject have been made in recent years which seem to possess unusual merit. In connection with his Report on the New York State Canal Survey, Mr. Emil Kuichling, M. Am. Soc. C. E., made an excellent study of flood flow on American and European streams. He obtained two equations which, with their corresponding curves, are shown on Fig. 1. It will be observed that the maximum rate of discharge is given per square mile in terms of the area of the basin in square miles and small areas have a much larger unit flow. Curve No. 1 corresponds to floods which may occur occasionally, while curve No. 2 corresponds to floods which may occur rarely. The discharges indicated by curve No. 2 are larger than given by some authorities and much larger than are provided for in many places in this country. The reason of the latter is sometimes because people have not had that rare flood which may reach them any day and against which many of them refuse to prepare until it has already occurred. The history of so many flood protection works is the story of a series of works with increased protection, the increased protection being added each time that a flood occurs larger than was expected. During the large flood which occurred in March, 1913, in the upper Scioto and Olentangy rivers, the discharge in each of these rivers at

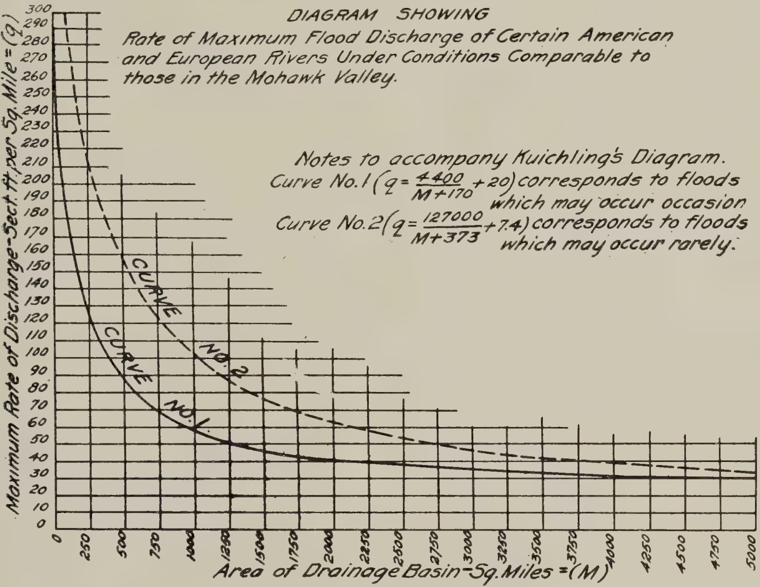
DIAGRAM SHOWING
Rate of Maximum Flood Discharge of Certain American and European Rivers Under Conditions Comparable to those in the Mohawk Valley.

Notes to accompany Kuichling's Diagram.
Curve No. 1 $\left(q = \frac{4400}{M+170} + 20\right)$ corresponds to floods which may occur occasion
Curve No. 2 $\left(q = \frac{127000}{M+373} + 7.4\right)$ corresponds to floods which may occur rarely.

Maximum Rate of Discharge-Sect. ft. per Sq. Mile = (q)
300
290
280
270
260
250
240
230
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
CURVE NO. 2
CURVE NO. 1
0
250
500
750
1000
1250
1500
1750
2000
2250
2500
2750
3000
3250
3500
3750
4000
4250
4500
4750
5000
Area of Drainage Basin-Sq. Miles = (M)

Fig. 1.

Columbus, Ohio, was roughly half way between the values given by the two curves. The Olentangy flows into the Scioto at Columbus. The discharge for the combined rivers is above the higher curve, or 90 second-feet per square mile with an area of 1,570 square miles, while Mr. Kuichling's curve No. 2 gives about 75 cubic second-feet for this area. (See report to City of Columbus on Flood Protection, by Alvord and Burdick, Hydraulic and Sanitary Engineers.) This would indicate that curve No. 2 is conservative. The flood at Columbus, while unprecedented for the Scioto River, would have been exceeded had the rainfall during March been moved only a short distance south or had there been snow on the ground. As it actually occurred, the belt of heaviest rainfall instead of covering the Scioto Valley covered only its upper portion, part of the belt extending across the watershed into the St. Lawrence basin.

Another excellent study which has been made recently was presented by Mr. Weston E. Fuller, M. Am. Soc. C. E., before the American Society of Civil Engineers and published in their Proceedings for May, 1913. Mr. Fuller's is a long and excellent article and he presents a large number of tables with data from nearly all parts of the country, which are of great value in looking up the discharges that may occur in any particular section. Mr. Fuller does not compare floods by getting the maximum discharge, but compares the average flow for the day of maximum discharge, a method which has also been used by the United States Geological Survey. This average flow is obtained by dividing the total discharge in twenty-four hours by the number of seconds in a day. It will here be called the twenty-four hour flow, in counter-distinction to the momentary flow. Mr. Fuller compares the maximum twenty-four hour flow with maximum momentary flows and also with what may be called average yearly flood flows.

Let Q (ave.)=average yearly flood flow obtained by getting the highest twenty-four hour flow for each year for a number of consecutive years and taking the mean expressed in second-feet.

Q=greatest twenty-four hour flow during a period of T years in second-feet.

Q (max.)=maximum momentary flow in second-feet.

T=the number of years in the period considered.

A=catchment area of the river in square miles.

For obtaining the relation between the flood to be expected in a series of years and the average yearly flood, he deduces the equation $Q = Q \text{ (ave.) } (1 + 0.8 \log. T)$ from which he computes the following table:

Table I.

Time in years.	Ratio of largest flood to average yearly flood.
1	1.00
5	1.56
10	1.80
25	2.12
50	2.36
100	2.60
500	3.16
1000	3.40

Mr. Fuller further, for getting the relation between the maximum momentary flow and the maximum twenty-four hour flow in the same flood, deduces the equation $Q \text{ (max.)} = Q\, (1 + 2A^{-0.3})$ from which he computes the following table:

Table II.

Catchment area in square miles.	Ratio of maximum flood to average 24-hour flood.
0.1	5.0
1.0	3.0
5.0	2.23
10.0	2.0
50.0	1.62
100.0	1.5
500.0	1.31
1000.0	1.25
5000.0	1.15
10000.0	1.12
50000.0	1.08
100000.0	1.06

Frequently, gage readings are available for a number of years and if discharge observations are available a rating curve may be made giving the relation between the discharge and the gage height. Rating curves for many points have been made by the Geological Survey. With the gage heights and the rating curve the value of Q (ave.) or the average yearly flood-flow may be determined, and by use of Table I the largest flood against which it is desired to protect can be determined. The flood which occurs once in a thousand years will frequently be the proper one to protect against, as the thousand-year flood may be near at hand. With the greatest twenty-four hour flood so obtained you may proceed to Table II and get the maximum momentary discharge and by going to the rating curve translate this back into gage heights if such is desired. Of course, one of the troubles with this method of Mr. Fuller's is in finding the value of Q, the average yearly flood-flow, as it is liable to be out badly unless the records for a long period of years are at hand; but, in any event, it is believed to be an excellent method of checking up results obtained by some other method, say by Mr. Kuichling's curves. It has the great advantage of including all the peculiarities of the catchment basin, including rainfall and melting snow and ice characteristics. It is also of value where there are no discharge observations or rating curve but otherwise sufficient gage records available. This is probably a very common case. The discharge for each gage height may be computed by use of Kutter's formulæ for the velocity $V=C\sqrt{RS}$ combined with the area of the cross-section. The area of the cross-section, the hydraulic mean depth, R, and slope, S, can be measured without waiting for a flood and by assuming n the coefficient of roughness, the value of C may be obtained from Trautwine's handbook or elsewhere. The rating curve may then be constructed, which is liable to be much in error due principally to the value of n assumed, and by using Mr. Fuller's methods this error tends to come out "in the wash" by the time the results are translated back into gage heights. Frequently it is the gage heights rather than the actual discharge observations that are desired.

In their report referred to above Messrs. Alvord and Burdick used gage records for sixteen years to find Q (ave.), the average yearly flood-flow for the upper Scioto, the Olentangy and the lower Scioto. Comparing these with the two highest floods on record the following ratios of Q (ave.) to Q are obtained:

Table III.

	1913 Flood.	1898 Flood.
Upper Scioto	3.52	2.23
Olentangy	3.52	2.20
Lower Scioto	3.52	2.22

The value 3.52 is slightly greater than the ratio, 3.40, Mr. Fuller gets in table I for 1,000 years. 2.20 is between his ratios for 25 and 50 years.

Mr. Kuichling's studies naturally fall down when applied to some stream like the St. Joseph emptying into the Maumee at Fort Wayne, Indiana. This stream has a porous soil and its maximum flood is only a fraction of that of the St. Marys River, the other tributary of the Maumee at Fort Wayne, although the St. Joseph has one half larger drainage area. In such a case the methods of Mr. Fuller would naturally apply. But if there is nothing unusual in the basin of the St. Marys it would be safe to say it might have Mr. Kuichling's curve 2 discharge some day. The Scioto River, near at hand with its flood discharge, would indicate this.

Mr. Fuller's and Mr. Kuichling's studies seem to lend themselves to rivers the size of many of our navigable ones as well as small streams. In some cases other formulas or methods involving time and money for investigation give more accurate results, but the methods here presented give prompt results and often very valuable assistance. These methods, however, do not provide any factor of safety, they only give the maximum load. The levee or the bridge must be built a certain number of feet above the crest of the flood to provide this. It is desired only to call attention here to the factor of safety; it is too complicated a problem to be discussed in a few lines. It may be the best business risk to provide only against the ordinary flood without any factor of safety added. The land power-houses at the Ohio River Locks are being built with the idea that occasional floods will drown out the machinery.

Light Bridge Equipage*

BY

Capt. W. G. CAPLES
Corps of Engineers

AUSTRIA.

Austria maintains no mounted engineers and, for that reason, assigns a unit of three wagons to each cavalry regiment of 900 sabres. The equipage provided is suitable for building three classes of bridge, viz,

a. Normal bridge; whole ponton supports, four balks per bay, three-panel roadway, suitable for the passage of all arms accompanying a cavalry division and the trains of the cavalry division. Each unit builds 60 feet of normal bridge, 7 feet 10 inches wide, 15-foot bays.

b. Horse bridge; whole ponton supports, three balks per bay, two-panel roadway, suitable for cavalry in file. Each unit builds 90 feet of horse bridge 5 feet 4 inches wide, 15-foot bays.

c. Footbridge; half-ponton supports, two balks per bay, one panel roadway, suitable for men on foot only, horses swimming below bridge. Each unit builds 162 feet of footbridge 2 feet 7 inches wide.

None of the bridges are very strong, even the normal bridge requiring that field guns shall be unhitched and moved across by hand, so that but little reliance is placed in them. A bridge lighter than a normal bridge requires the troops to separate themselves from ammunition, baggage, and provisions, which makes the use of any bridge other than the normal one more theoretical than practical. A cavalry division of four regiments is then limited to 240 feet of bridge suitable for its needs.

The Austrians recognize this condition, and make ferrying the normal and bridges the exceptional means of crossing streams. Each unit is designed to build two landing stages and a trail or a rope ferry consisting of two or three pontons. The normal ferry consists of three pontons lashed gunwale to gunwale and decked over. It will carry either:

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*Report made to the Board on Engineer Troops.

6 horses and riders completely equipped; or,
2 guns and limbers without horses; or,
2 field wagons and 25 men; or,
55 armed men; or,
66 unarmed men.

The light ferry will carry about two-thirds the same load, but its practicability is questionable. The passage of a cavalry division across a stream of any magnitude will require from a day to two days, depending upon whether the horses are swum or not.

The pontons are of the half-boat type, with a sheer extending one-third their length and a bow extending the same length. They are built of steel frames covered with galvanized sheet steel. A flooring of three fir plank covers the inside of the bottom of the boat and two chafing battens run one on each side. There are no battens on the bottom of the boats. The stern of each half-boat has a groove cut to receive the saddles, thereby reducing the allowable immersion. The pontons draw, light, about an inch and a half. Each half-boat is of the following description:

Length	10 feet 10 inches.
Beam	4 feet 7 inches.
Depth	2 feet 0 inches.
Thickness of skin, approximately	0.025 inch.
Weight	409 pounds.
Displacement	4,840 pounds.

The half-boat was selected instead of the Birago type because the body sections of the latter can not be navigated and do not form as good a boat part as a section with a modeled end. For purposes of transportation, the half-boats are inverted and placed stern to stern on transoms crossing a wagon frame, the attachment to the transoms being by bolt and key. This arrangement gives a low center of gravity to the load, but subjects the boats to the maximum strain in traveling and takes considerable road space, the distance from the tongue of a wagon to the bow of the rear half-ponton being 30 feet.

Saddles are retained in order to get the maximum length of bay for a given length of balk, but a marked departure is made from the Birago system in that the saddles are let into the pontons so as to bring their tops flush with the gunwales, permitting the balk to rest on the gunwales as well as on the saddles. The reason assigned for this change is that balk resting only on saddles are subject to oscillations greater than this class of bridge equipage can stand, a fact that was recognized forty years earlier by our Duane Board when it definitely rejected the Birago system. Saddles are used also for abutment sills and have claws at each end and rings for carrying. They are made of fir with metal bound ends, and have the following dimensions:

Length	7 feet 10 inches.
Depth	5 inches.
Width	3 feet 5 inches.
Weight	33 pounds.

The floor system consists of balk which carry a combination of chess, half chess, and panels. The balk and panels form the principal flooring, the half-chess and chess being used to form only a small part of the floor. These pieces are made of fir or hackmatack, except that parts subject to specially heavy wear are made of beech. The balk are all claw balk with rings in the end for carrying. The half-chess and chess are covered with cleats for fitting into the bridge floor and for improvising additional trestles. The panels are composed of four plank, about 1 inch thick, screwed to two strips at each end, the strips being about 1 by 1 inch. The inner strips project about 1 inch to form a lock between adjacent panels in the bridge. The dimensions of the various pieces are as follows:

	Dimension.	Wt. in lbs.
Balk	15 feet 8 inches by 5 inches by 3.5 inches	62
Chess	10 feet 6 inches by 5 inches by 1.25 inches	20
Long half chess	7 feet 10 inches by 5 inches by 1.25 inches	14
Short half chess	5 feet 3 inches by 5 inches by 1.25 inches	8
Panels	3 feet 2.5 inches by 2 feet 7.5 inches	30

Trestles are maintained as an important feature and apparently rightly so; for a boat with a skin only half again as thick as a tomato can will stand very little rubbing on stones or snags and, if the galvanizing is scratched, will soon rust until it is worthless.

The trestles used are of the Birago type, the only notable difference between them and the Birago being that the outer legs are not so long as the inner ones and that the shoes are circular lenses.

The wood used is generally fir. The dimensions of the various parts are:

	Dimensions.	Weight, pounds.
Cap	10 feet 11 inches by 6 feet 7 inches by 5 inches	93
Long legs	14 feet 5 inches by 3.5 inches by 2.7 inches	30
Short legs	9 feet 2 inches by 3.5 inches by 2.7 inches	18
Shoes	10 inches diameter, 1.6 inches thick at center tapering to sharp edge	4
Chains	6 feet 7 inches long	11

The ponton wagons themselves are identical and built to give great flexibility, so that any wheel can pass over an obstruction 20 inches high. The track is 5 feet. The loading is arranged to keep low centers of gravity, so that any wagon can travel along the side of a 31 degree slope without overturning. The three wagons of a unit each carry two half-pontons, but the remainder of their loads are made up so as to equalize weights. The distribution of loads is such that if one wagon is lost the whole unit is practically out of commission; if trains should be formed, they must consist of multiples of three wagons. In each unit the wagons are designated as Nos. 1, 2, and 3. Nos. 1 and 2 receive an identical loading, while No. 3 is differently loaded. The details of loading are as shown by the table on page 260.

No.	Name of Piece.	*Weight, pounds.	Wagons, Nos. 1 and 2.	Wagon No. 3.
	Wagon, stripped	1067	1	1
	Wagon Parts.			
1	Doubletree	15		1
1	Tongue	31		1
2	Front transoms for Nos. 1 and 2	6	1	
2	Rear transoms for Nos. 1 and 2	13	1	
1	Front transom for No. 3	4		1
1	Rear transom for No. 3	14		1
1	Middle transom for No. 3	5		1
1	37.4-inch wheel	70		1
2	49.5-inch wheels	86	1	
3	Locking chains, complete	18	1	1
2	Anchor transoms	6	1	
1	Clamp	6		1
2	Shovels	4	1	
3	Hand axes	3	1	1
3	M 86 tin oil cans	2	1	1
12	Wagon bed braces	7	4	4
	Testles and Flooring.			
20	Balk	62	10	
4	Short legs	18		4
2	Long legs	30	1	
4	Suspension chains	11		4
4	Short half chess	8		4
12	Long half chess	14	4	4
4	Short chess	14		4
8	Long chess	20		8
48	Panels	30	15	18
4	Shoes	4		4
2	Trestle caps	93		2
4	Saddles	33		4
	Pontons and Accessories.			
2	Anchors	66	1	
6	Half-pontons	409	2	2
18	Row locks	2	6	6
3	Boat hooks	6	1	1
3	Rack sticks	1	1	1
12	Cars	8	4	4
6	Scoops	3	2	2
	Ropes and Accessories.			
50	Short mooring ropes	¼	10	30
30	Long mooring ropes	1	15	
4	Anchor ropes	11	2	
1	Double anchor rope	22		1
20	Wedge keys	1		20
10	Pickets	5	4	2
1	Ferry trolley	1		1
4	Mauls	10	1	2
	Weight of bridge material carried	pounds	*2151	*2205
	Total loaded weight	pounds	*3374	*3458
	Load in pounds per horse		*844	*865

*To nearest pound.

A very noticeable defect is that only two anchors are carried with three floats. To make up for this, the Austrians stretch a cable across the stream and make fast the pontons to it by means of the mooring ropes. If the horses are to be swum, no down stream anchors are cast, making the bridge very rickety at best. No ferry rope is listed in the prescribed equipment but one is probably carried, since the manuals prescribe stretching two ropes across the stream and securing them by anchors held between two pickets and pickets alone on alternate ends. The ferry pulley is very light (1.09 pounds) and apparently can not take a large rope nor stand a severe strain. It looks as if a stream of any consequence would have to be crossed by rowing the raft. As only four oars can be used in the three-ponton raft, rowing would greatly increase the time of passage. If a cavalry division of only 3,600 sabres—probably not over 5,000 men total—takes from one to two days to cross a stream, its offensive and scouting power is seriously crippled while, in the event that it is driven back across a stream, the delay seems to invite disaster. The Austrians appear to be getting a very limited return for the twelve wagons and forty-eight horses that they assign to the bridge equipage of a cavalry division.

The reasons for the equipage adopted are given by its designer, Major Herbert, and are as follows: The Austrian War Office took the position that cavalry must have an independent bridge equipage, that swimming sacks and similar devices are only makeshifts, that regular pontons on wagons must be carried and that the equipage must be as light as possible, but it should not be expected to travel faster than a walk. The designer tried to meet these conditions, to make as few changes as possible from the Birago system, and to make the equipage adaptable to as many kinds of bridges as possible—a sort of universal tool, as it were. The designer's reasons for the selection of steel for his pontons were that the Austrian efforts to use canvas boats had not met with success, that aluminum is too uncertain and expensive, that "wooden pontons must be abandoned as they are decidedly out of date" and because steel is the most suitable material—reasons that would seem to require more explanation than the bald statements given.

GERMANY.

Germany has adopted a cavalry bridge equipage for much the same reasons as Austria. The German design, made by Major

Scharr, follows the Austrian system rather closely but with many improvements in details. Notable among the improvements are that each wagon constitutes an independent unit, that the flooring is made into long panels instead of a great mixture of pieces, that more anchors are carried, and that the mode of loading gives the boats less strain and requires less road space for the wagons than in the Austrian system. No trestles are provided but rules are given for improvising them, a difference that is in favor of the Austrian system.

Each regiment of German cavalry (600 sabres) is assigned two ponton wagons, which carry not only the bridge but also the demolition and repair equipment and fireless-cookers. Each wagon carries two half-pontons and flooring for one and one-third bays of normal bridge. The two wagons assigned to a regiment can build, then, two bays of normal bridge and a third bay of equal strength but only of two-thirds normal width. The normal length of a bay is 13 feet. When saddles are used, a bay can be obtained from each ponton but the bridge so built is very unstable, so that normally two pontons are used to each bay, the claws on the balks engaging the gunwales of two pontons. The equipage carried with a cavalry division (six regiments) is theoretically able to build three types of bridges, viz,

a. Normal bridge: one whole ponton to each bay, using saddles; three-panel roadway, 157 feet 6 inches long, 9 feet 10 inches wide, able to carry cavalry in file, men leading horses; guns and wagons with two horses, men leading animals. One ponton is generally kept out to look after the anchors.

b. Light bridge: half pontons alternating with pontons, two-panel roadway, 221 feet long, 6 feet 3 inches wide, able to take cavalry in file at extended distances and light vehicles drawn by hand.

c. Footbridge: half pontons, one panel roadway, 325 feet long by 3 feet 4 inches wide, able to carry cavalry at extended distances, the horses being swum below the bridge.

The footbridge is largely theoretical, for the bridge vibrates badly and the pontons go down by the head even in very mild currents. It is open to the same objections as the Austrian bridges as to separation of the command from its supplies. The light bridge may be suited for short raids where no artillery is needed, but it is not often that anything else than the normal bridge will be built. The normal bridge can be laid in an hour while the total delay to the column with such a bridge will be about two hours, not counting any delay on account of the removal of the bridge. The Germans therefore lay great stress upon the construction of the bridge and provide an ample supply of anchors and accessories to make the bridge rigid. For a stream more than 325 feet wide, however, resort will have to be made to ferries.

The Germans count more upon row ferries than upon the other types. A ferry is composed of two boats and four panels, manned by four oars. A ferry will carry, at each trip, either:

1 field gun without horses and with gun crew; or,
4 cavalrymen with horses; or,
1 field wagon; or,
50 horse equipments and packs; or,
30 men fully armed.

The Germans favor swimming the horses. A passage by ferrying will require from fifteen to thirty hours, depending upon conditions.

The pontons are of the half-boat type with flat gunwales, bow extending back one-third the length. Each half-boat has thirteen frames of mild steel and is covered with thin galvanized steel. Five strips of fir, about 5 inches by 1 inch, form the floor. The bottom is provided with three fir chafing-battens, about 1 inch by 1 inch, and a similar batten is provided at each side. The gunwales are bored to receive oarlocks, hand-rail stanchions, and saddles. Sockets are arranged on the sides to receive the tenons of the balks when forming a raft. The width of the gunwale is such that the claw of a balk can grip two gunwales, enabling two pontons to be brought alongside and used for a single support, the saddles being omitted when a strong bridge is desired. The half-pontons have the following characteristics:

Length	10 feet 6 inches.
Beam	4 feet 11 inches.
Depth	2 feet 0 inches.
Thickness of skin	0.024 inch.
Weight	341 pounds.
*Displacement	4,900 pounds.
*Displacement, 6 inches below gunwale	4,000 pounds.

Saddles serve also as abutment sills and are constructed of fir; dimensions 11 feet 2 inches by 6 inches by 2.4 inches. Weight, 44 pounds. Each end of a saddle has a tenon that engages in holes

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*Approximate. Figured roughly from drawing in *Feld Pionierdienst Aller Waffen.*

bored in the gunwale of the half-pontons. The ends are metal bound.

The floor system is made up into panels, 13 feet 1 inch by 3 feet 3 inches (4 by 1 meters) and weighing 203 pounds. The material used is fir throughout. Each panel has three balk, 13 feet 1 inch by 5 feet 5 inches by 2.5 inches, with claws and tenons on the ends of the two outer balk. The chess are 3 feet 3 inches by 8 inches by 0.78 inch and are screwed permanently to the balk. A metal clamp, called a stiffener, enables a chess to be clamped perpendicular to the axis of the panels and to the balk at the center of the panel to give stiffness. The weight of a stiffener is 97 pounds.

The load on each ponton wagon is as follows:

A. Bridge Material.

	Pounds.
2 half pontons	682
3 saddles	132
4 panels	810
2 stiffeners	194
3 hand rail stanchions	12
1 anchor	66
3 short pickets	3
3 long pickets	4
6 oars	53
6 oar locks	5
4 boat hooks	31
2 anchor ropes	29
8 general rail ropes	9
4 lashings	1
Weight of bridge material	2,041

B. Tools.

1 axe.
2 hatchets.
1 pick.
2 spades.
1 saw.

C. Mess Equipment.

18 rations.
2 fireless cookers.

D. Demolition Equipment.

16 explosive cartridges.
16 capped fuses.
4 long capped fuses.
20 loose caps.
1 pulley.
1 wire cutter.

E. Repair Kit.

100 nickel rivets, 1 inch by 2.5 inches.
100 nickel rivets, 1.2 inches by 3.5 inches.
1 plate shears (probably trimmers snips).

1 punch (literally: ''Hole-through-blow'').
1 holding-on tool (literally: ''Rivet-shaker'').
1 rivet set (literally: ''Rivet-hold-before'').
1 rivet hammer.
1 rivet header (literally: ''rivet-drawer'').
1 soldering iron (literally: ''solder-club'').
1 solder, pound.
⅛ litre soldering fluid in rubber flask.
2 steel plates.

The weights of the empty wagon and of the tools and kits have not been obtainable. Probably the loaded wagon weighs about 3,600 pounds, as it is drawn by four horses.

DENMARK AND BRAZIL.

The Danish equipment, devised in 1907 by Captain Christensen and later adopted by Brazil, goes a step further than the preceding systems, in that it combines the floating supports and the roadway. The equipage is made up of rafts. Each raft consists of four wooden boxes bound together and permanently decked over, forming a raft with a hollow center. The rafts have the following characteristics:

Length	6 feet 7 inches (2 meters).
Breadth	3 feet 7 inches (1.1 meters).
Weight	176 pounds.
Displacement (total)	913 pounds.
Displacement (net)	737 pounds.

The wooden boxes are made of American pine (25 pounds per cubic foot) with oak knee-braces. The caulking is of wax and is claimed to have been found satisfactory after four years service. Side rails are provided by hinged planks on the shorter edges of each raft.

The bridge is constructed by bringing together the rafts and shoving them off in the water. Anchors are laid from one of the rafts and the rope brought down to bridge. When constructed the bridge blocks the stream completely, there being no space between the rafts except the little gap provided by the hinges. All illustrations of the equipage in use show it thrown across a quiet pond or a stream with practically no current.

The rafts are carried on two-wheeled carts, drawn by one animal. Each cart carries two rafts. The rafts may be carried on wagons, eight to a wagon, drawn by two animals. A full description of the system and of the equipment is on file with the Board, but the defects of the system are so obvious that a fuller description is not embodied in this report.

OTHER NATIONS.

England has a folding canvas ponton boat smaller and lighter than ours and intended for lighter work. Russia has the canvas ponton just as it existed sixty years ago, before it was taken up and improved in our service. No reports have been found to indicate that a light-bridge equipage is used by any other nation.

CONCLUSIONS.

There seems to be nothing in the foreign light-bridge equipage to indicate that they are as good as our own. The only feature which they have and we do not is the ability to construct a number of types of bridge with the same equipage, a thing that seems to have been a hobby with the European designers for many years. This ability can scarcely be called an advantage for, if the bridge is not strong enough to cross its own wagons and animals, it has no value except in a hurried raid of very short radius where a ferry would serve the purpose equally well as a bridge. If a considerable body is to be passed over, the bridge must be able to carry its artillery and trains, which is a task for the heaviest bridge that the European cavalry equipages can build. The Austrian equipage has one feature that we might add to our own, a ferry pulley. The German equipage, while generally an improvement over the Austrian in every way, offers nothing for our equipment. The Danish and Brazilian equipment does not seem to be practical. A bridge that blocks the stream can not be used where there is any current. Wooden boxes, with no means of bailing, however well caulked, do not inspire confidence. We have already improved the Russian boat. The English boat is intended for a class of work that is lighter than we attempt.

The light wagons of the European equipages still require four horses, which is all that our wagons take. The following table compares the light trains of Austria, Germany and the United States.

	Length of bay.	Displacement of pontons.	Feet of bridge per wagon.	Heaviest loaded wagon.
	Feet.	*Pounds.*		*Pounds.*
Austria	15.0	9,680	20.0	3,458
Germany	13.0	9,800	13.3	3,600
United States	15.5	9,960	15.5	3,810

Our equipage gives a larger and stronger bridge for the same weight than either of the European equipages. The feet of bridge per wagon with the Austrian equipage is rather misleading as half of this bridge must be on trestles, a system that our Civil War showed to be unsatisfactory. If trestles are used only to keep the pontons from grounding, as in our system, the Austrians would have only about 11 feet of bridge per wagon. The heaviest load in our advance guard is the trestle wagon. Excluding trestle wagons, the heaviest loaded wagons in the three trains are:

Austria	pounds	3,374
Germany	pounds	3,600
United States	pounds	3,635

The slightly lighter wagons of the European equipages build bridges that are decidedly weaker than our train builds. The bridge built by our advance guard train will carry an army; as was proved in General Sherman's march from Chattanooga to Atlanta and beyond when he had only canvas pontons; while the advocates of the European cavalry equipages do not claim that they will do more than pass a cavalry division. The trouble with the European equipages is that their floor systems are too light. So long as the heaviest wagon in our advance guard train weighs less than the cavalry's field wagons, carrying their food and forage, and is drawn by an equal number of mules, it is safe to say that our pontons can keep pace with our cavalry.

The well-known weaknesses of the canvas ponton are its liability to puncture and its certainty to leak badly after a few days in the water. As to the first, it is questionable if the heavy canvas that we use will puncture much quicker than the extremely thin skins of the European boats. Even if it should puncture a little more readily there is no comparison as to the ease of stopping and repairing leaks. A sheet of steel only a little thicker than a common tin can will rust through in a hurry, once it is exposed. European manufacturers may be able to make a galvanizing that will stick but our manufacturers can not do this. If the boats are not absolutely protected from rust, it is a matter of only a little time until a thin steel ponton will be eaten through. As to leaking after a few days in the water, this objection is a minor one. If the cavalry division moves on, leaving no guard, the bridge must move with it, while, if a guard be left, the bridge will be replaced by a reserve bridge in a few days and then move on to rejoin the cavalry.

Our pontons have stood the test of war while the European cavalry equipages are products of the last ten years and have never been tried under war conditions. The Duane Board said of our boat:

> With regard to the canvas boat, it soon became apparent that it was precisely what we required for the advance guard train. It is light, simple, strong, easily repaired, and when packed can safely be transported with the superstructure of the bridge as rapidly as any column of troops can move.
>
> And,
>
> The only ponton train carried by the Army of the Cumberland from Chattanooga to Atlanta, and thence to Savannah and Washington, was composed of hinged canvas pontons, and it gave general satisfaction.

Summed up, our canvas pontons give loads as light practically as the lightest European trains, build larger and stronger bridges than the European trains of equal size, and have stood the test of actual war while the European trains are more or less experimental novelties. The European boats do not leak so much and possibly do not puncture so readily, but the canvas ponton does not rust. The free-board of our pontons is greater and our floor systems are stronger than those of European cavalry equipages. It does not appear advisable to exchange an article of proved merit for one that does not appear to be even equally good, simply because the latter bears the stamp of German approval.

Book Reviews

TECHNIQUE OF MODERN TACTICS. A Study of Troop Leading Methods in the Operations of All Arms. By Majors P. S. Bond and M. J. McDonough, Corps of Engineers, U. S. Army. 344 pages, 16 plates. George Banta Publishing Co. *Price,* $2.65 postpaid.

The purpose of this volume, as stated by the authors in their introduction, is to "supply in compact form the help needed by the instructor—or the student working alone—in the applicatory method of study. It is not intended as a text alone; its principal rôle is that of a guide to those engaged in the study of practical problems in tactics, either as instructor or student—for the preparation or solution of those problems. It is believed to be the only single work overlooking, from this point of view, the entire field of minor tactics. Nearly everything contained in this volume can be found elaborated in special treatises, but time is of value to the military student and this work gives in a single volume authoritively the data that must otherwise be searched for through a small library."

This purpose has been admirably accomplished; and it is believed that the book will form a valuable reference for officers who wish to prepare for the course at the Army Service Schools or the War College, or for duty in charge of garrison schools, militia instruction, field maneuvers, war games, the preparation of lectures and problems, etc.

An idea of the scope of the work is given by the following list of chapters: the preparation and solution of tactical problems; field orders; patrolling; advance guards; rear guards; flank guards; marches, change of direction of march, camps and bivouacs; convoys; artillery tactics; cavalry tactics; outposts; combat, attack and defense; organization of a defensive position; combat—attack and defense of a river line, withdrawal from action, rencontre or meeting engagement, delaying action, night attacks, machine guns; a position in readiness; sanitary tactics; the rifle in war; notes on division tactics and supply.

The chapter on the organization of a defensive position is of special interest to Engineer officers, and contains two problems with solutions and maps.

The book is well printed and bound and should form a valuable addition to an officer's library.—J. A. W.

Nearly a third of a century has elapsed since the School of Application for Infantry and Cavalry, the progenitor of the present Army Service Schools, was founded at Fort Leavenworth, Kansas. From a modest beginning with dependence only upon such foreign text-books in the English language as were then available, the Service Schools have steadily and consistently progressed, creating an atmosphere of their own, until to-day they hold equal rank with any institutions in the world with similar purposes.

One of the most significant signs of the progress of these schools is the appearance in the field of military literature of a number of works by their graduates, works which have compelled attention and which have reflected well-deserved credit and honor both on the authors and the schools. "Sherrill's Military Topography," "Eames' Rifle in War," "Hanna's Tactical Decisions and Problems," not to mention others, bear ample testimony to the excellent work of the Army Service Schools.

This latest work on tactics by Majors Bond and McDonough is a frank and avowed exponent of the "Leavenworth Idea," and will unquestionably prove a welcome and timely addition to the series of excellent works which have owed their inception to the work of the Service Schools. Perhaps the character of the work would have been more fittingly indicated by the title "A Key to the Solution of Tactical Problems," for it is with special reference to the solution of tactical problems as taught and practiced at Fort Leavenworth that the volume has been prepared. The various classes of tactical problems are treated in separate chapters, the accepted tactical rules and principles being stated in simple, direct, and unequivocal language, and followed by practical examples.

In the 344 pages of text and 15 figures, including maps, the authors have provided what might be termed a concentrated extract of the teachings of the recognized authorities in the art of war and tactics, as interpreted and taught at the Army Service Schools.

For those who are seeking to improve themselves by self study or to prepare for the Service Schools or Army War College, the work will be invaluable and will save much reading of Griepenkurl, Von Alten, Balck, Kiesling, and the host of other writers on tactics.

That so excellent a work, bearing on its face evidence of painstaking labors, could have been produced in the midst of their school course, reflects great credit upon the ability and industry of the authors. That it should have been the work of two officers of the Corps of Engineers is gratifying indication of the growth of the spirit of cooperation and coordination between the different arms of the service, which feature also is one of the good fruits of the Army Service Schools.—J. E. K.

ESSAIS SUR LA GUERRE RUSSO-JAPANAISE. Par le Capitaine De Saligny d l'Infanterie Coloniale. 462 pages text with 5 folding maps. Paris, 1913. Berger-Levrault.

It is inevitable that so important a war as that between Russia and Japan in 1904-1905 should attract the interest of the military student and writer. A decade has now elapsed since the first gun was fired and a veritable flood of literature has made its appearance, including the monumental official report of the Russian General Staff and the critical and scholarly writings of Major von Tettan.

In the work now before us, Captain De Saligny has endeavored to analyze the lessons to be learned and the causes of the Russian defeat. The work is divided into three books: the first, 177 pages, devoted to a sketch of the events of the war; the second, 61 pages, to the lessons of the war; the third, 204 pages, to the causes of the Russian defeat.

In a brief preface by General Lacroix, the author is accorded high praise for his exhaustive and critical study, which involved an extensive and thorough reading of all noteworthy available literature. This praise is well merited, for no one who reads Captain De Saligny's work can fail to be impressed by his painstaking labors and the soundness of his deductions.

While much space is devoted to the causes of the Russian defeat and much of interest is presented in detail, the final impression that forms on the mind is simply that the Russians, although superior numerically and better equipped, were lacking in energy, morale and training as compared with their adversary.

Captain De Saligny's excellent work is commended to all who may wish to obtain a clear picture of the events of the war and an impartial judgment as to the lessons taught by it, without reading the more monumental and detailed official account of the Russian General Staff.—J. E. K.

Editorial Notes

Failure of the Stoney River Dam

The dam across Stoney River at Dobbin, W. Va., failed on January 15. It belonged to the West Virginia Pulp and Paper Company and had been completed during the past summer. It was a storage dam over 1,600 feet long and the point of failure was not in the spillway. The dam was hollow reinforced-concrete of the Ambursen type which, as is well known, is essentially triangular in cross-section, the base of the triangle being a little wider than its height in this case. For a length of the dam with constant depth, the base is a thin continuous slab as wide as the dam and placed horizontally under it. The upstream face of the dam is an inclined slab and is also continuous. At the point of failure the height of the dam was in the neighborhood of 25 feet from its base to the top. Its base was somewhat wider than this. A 2½-foot thick cut-off wall extended along the upstream edge of the base and to a depth of 5 feet below it. The structure rested on what the engineers called hard-pan, although it is referred to also as yellow clay. Some distance below the cut-off was a shale bed to which the cut-off wall extended in some parts of the dam which were not damaged. Only 8 inches below the cut-off wall, according to the *Engineering Record,* a pervious seam of coal and sand with some clay and binder was found. This seam was from ½ to 6 inches thick and about 4 feet wide. A leak started through this seam which washed until enough material was carried out from under the dam to allow it to settle at the point, the rushing water thereafter tearing out some of the dam on each side. The failure was in no sense dependent on the type of dam. The water percolated through the bad seam in such quantity that it washed the material, and the result was but a question of time. It appears that the engineers did not make sufficient investigations into the foundation to be aware of this poor seam of material, but even if all the material above the rock had been of the type of clayey hard-pan which it was thought to be, the construction was very questionable. This dam adds just one more to the number which have failed recently due to failure of their foundations.

Bibliography of the Mexican War

With this number the Professional Memoirs has made an innovation, by issuing as supplement No. 1 an important pamphlet, separately bound, consisting of a bibliography on the war with Mexico, 1846-1848, together with a select list of books and other printed material on the resources, economic conditions, politics and government of the Republic of Mexico and the characteristics of the Mexican people.

The bibliography was prepared by Mr. Henry E. Haferkorn, Librarian, United States Engineer School.

This bibliography is the first one on this subject which has come to our attention containing annotations and what librarians term "full" title entries. There are numerous publications, but all have only "short" entries and in most cases lack the bibliographical data including imprints, paging, illustrations, etc. The full form gives considerable information and was adopted in order that persons in places remote from library facilities might be able to select the books needed for a particular purpose.

The selection of works included in the bibliography was made on a basis of the bibliography contained in the following standard works:

James Russel Soley. The wars of the United States, 1789-1850 (being Vol. VII of Just. Winsor's Narrative and critical history of America), and

Jos. Nelson Larned's Literature of American History.

The bibliography presented is divided into eight sections or divisions, viz,

1. Choice works dealing with the History of Mexico in general.
2. General histories of the War 1846-48, including also studies of the war from a political standpoint.
   2a. Works relating to the Conquest of California and New Mexico.
3. Special campaigns and battles. Personal narratives. Regimental histories.
4. Biographical material. (Lives of prominent characters of the Mexican War, including a few works relating to Porfirio Diaz, late President of Mexico.
5. The Navy. Works dealing with naval operations of the Mexican War.

6. Modern Mexico. Including description of, and travel in, Mexico; natural resources, social life and customs, politics and government, economic conditions, the army and navy, recent events.
7. Means of communication: Railroads, roads and trails, canals, inland waterways, rivers, seaports, posts and telegraphs and other public works.

This bibliography is issued free to the regular subscribers of the MEMOIRS. The publishers, as well as the subscribers, of the MEMOIRS are under great obligations to Mr. Haferkorn for the privilege of publishing the work in this way. For any additional copies desired or for copies desired for anyone other than the regular subscribers a charge of 50 cents per copy will be made.

This is entirely independent of the regular charge of 60 cents which will be made for an extra copy of this number of the PROFESSIONAL MEMOIRS without the supplement.

Erratum

On page 100 of the January-February, 1914 (No. 25), issue of PROFESSIONAL MEMOIRS, because of an omission made by the Editor of the MEMOIRS, the last paragraph has been made meaningless by being disconnected and having no reference to the matter immediately preceding. It should therefore be stricken from the article.

PROFESSIONAL MEMOIRS

Corps of Engineers, United States Army, and Engineer Department at Large

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Maj. FREDERICK W. ALTSTAETTER, *Editor.* Lieut. EARL J. ATKISSON, *Business Manager.*

VOL. VI. MAY-JUNE, 1914. NO. 27.

Contents

(*Illustrations in each article are shown by italics.*)

Page.

1. ROAD AND TRAIL CONSTRUCTION IN ALASKA 275-320
   By Maj. F. A. Pope, Corps of Engineers; ex-member Alaska Road Commission.
   - *Klutina Bridge, Valdez-Fairbanks Road* 281
   - *Along Tonsina River, Valdez-Fairbanks Road* 287
   - *Portage Road, Prince of Wales Island* 289
   - *Duggan Creek Bridge, Fairbanks-Fort Gibbon Sled Road* 293
   - *Grader at work on local road near Nome* 299
   - *U. S. Mail, near Golovin, en route to St. Michael* 313
   - *Mail stage at summit Alaskan Range on the Valdez-Fairbanks Road* 317
   - *Map of Alaska* 319
2. FIELD METHODS FOR PRINTING FROM METAL 321-332
   By Mr. Hermann E. Osann, Late Chief Lithographer, Army Service Schools.
3. SOME DAMAGE BY THE LAKE STORM, NOVEMBER, 1913 333-344
   By Lieut. Col. M. M. Patrick, Corps of Engineers; M. Am. Soc. C. E.
   - *Steamship John A. McGean* 335
   - *Steamer Charles S. Price "turned turtle."* 337
   - *Harbor of Refuge, Harbor Beach, Michigan* 339
   - *Cross section of Superstructure, Main Breakwater, Harbor Beach* 340
   - *Block No. 38, Main Pier, Harbor Beach* 342
   - *Damage to Concrete Superstructure, Main Pier, Harbor of Refuge* 343
   - *Damage to Main Pier, Harbor of Refuge, Harbor Beach, Mich.* 343
   - *Proposed Riprap* 344
4. DAMAGE TO HARBOR WORKS IN THE CLEVELAND, O., ENGINEER DISTRICT CAUSED BY THE STORM OF NOVEMBER, 1913 345-357
   By Mr. R. B. Perry, Junior Engineer.
   - *Cleveland Breakwater; typical timber section* 347
   - *First type of rubble mound, Cleveland Breakwater* 349-351
   - *Cleveland Breakwater; first modification and design now followed* 353
   - *Cleveland Breakwater; rough type of covering* 354
   - *Present type of rubble-mound breakwater* 354
   - *Views of the earlier types of rubble-mound breakwaters* 355-356
   - *Views along the old timber breakwater, Cleveland Harbor* 357
5. THE ENGINEERS WITH GENERAL SHERMAN'S ARMY 358-394
   Reports by Gen. O. M. Poe, and by Maj. Hubbard, Twelfth Missouri Cavalry, with introduction by Lieut. Col. W. E. Craighill, Corps of Engineers.
6. CYLINDRICAL VALVES, AND AUTOMATIC CRESTS OF DAMS .. 395-402
   By Gen. W. L. Marshall.
7. TANK CAR WATER SUPPLY FOR TROOPS ON THE MARCH 403-407
   By Lieut. O. N. Sohlberg, Corps of Engineers.
8. ALEXANDER DALLAS BACHE. (See Frontispiece) 408-409
   By Lieut. Paul Sorg Reinecke, Corps of Engineers, U. S. A.
9. THE ENLARGEMENT OF GOVERNORS ISLAND 410-422
   By Mr. Henry Nash Babcock, Assistant Engineer.
   - *General views of Governors Island* 413-415
   - *Governors Island extension sea wall* 419
10. FLOOD PREVENTION 423-438
    By Maj. J. C. Oakes, Corps of Engineers; M. Am. Soc. C. E.
11. AN ICE COFFERDAM 439-440
    By Lieut. Col. Chas. L. Potter, Corps of Engineers, U. S. A.
12. BOOK REVIEWS 441-443
13. EDITORIAL NOTE 444
    - Students' Summer Military Camps 444
    - Erratum 444
14. SELECTED ARTICLES OF ENGINEERING INTEREST .... viii-xiii
    Compiled by Mr. Henry E. Haferkorn, Librarian, Engineer School.

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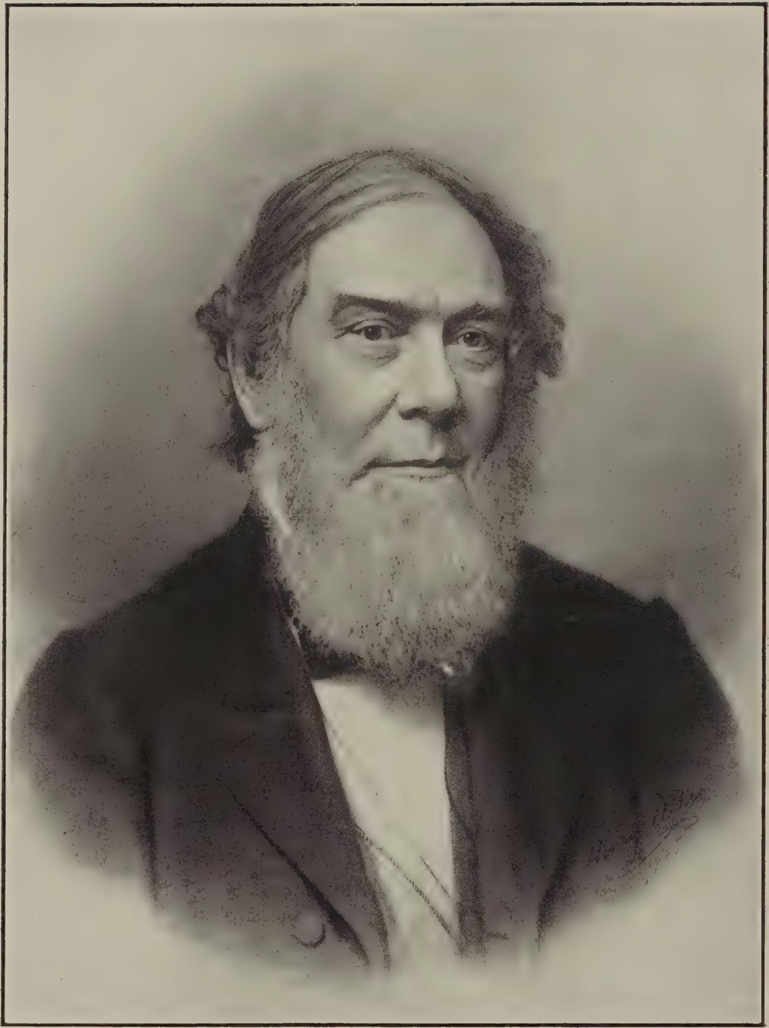


ALEXANDER DALLAS BACHE

CADET U. S. M. A., 1821-1825

SECOND LIEUTENANT OF ENGINEERS, 1825-1829

SEE PAGE 408

Road and Trail Construction in Alaska

BY

Maj. F. A. POPE
Corps of Engineers; ex-member Alaska Road Commission

As Alaska has an area about one-fifth as large as that of the main part of the United States and faces both the Arctic and Pacific oceans, a considerable variation in topography, climatic conditions and resources is to be expected. The most striking topographical feature, and the most important in its effect on the climate, is the Coast Range. This range, nowhere more than a few miles from the coast, forms a continuous barrier from Portland Canal, the southern boundary, to the Aleutian Islands. The only break, beside a few narrow river passes, is Cook Inlet.

In southeastern Alaska, between the mainland and the open sea, are a great number of rocky and mountainous islands forming the most important part of that section of the territory. There are a number of islands along the south and southwest coast extending out to the Aleutian Islands, which reach almost to the mainland of Asia. The whole area south of the Coast Range is mountainous, except a few river valleys and a few level benches on the islands.

North of the Coast Range are the basins of the Copper and Susitna rivers, mostly rolling country except for the flat benches along the Copper River. Beyond this area is the Alaskan Range, which extends under various names from the Coast Range west of Cook Inlet to the same range near the Canadian border.

Near the 68th parallel the Arctic Range, under various names, extends pretty well across the territory from East to West.

Seward Peninsula is mountainous, with a number of river valleys. There are a number of islands in Bering Sea.

Between the Alaskan and Arctic mountains is the great central valley of Alaska extending from Canada to Bering Sea, and containing the basins of the Yukon, Kuskokwim and Kobuk and a number of smaller rivers. The country is generally level for some distance back from the rivers and from Bering Sea, and in other places rolling or hilly.

It is doubtful if any equal area anywhere else in the world has as great a diversity in climatic conditions as Alaska. The climate of the coast from the Aleutian Islands to the borders of British Columbia is tempered by the warm, moisture-laden winds from the Japan Current, resulting in temperatures almost as high as in the same latitudes in western Europe. The barrier of the Coast Range stops these winds and causes the precipitation of their moisture on the narrow coastal strip and adjacent islands. The result is a climate very similar to that of Scotland or southern Norway, with, in most places, a great deal more rain or snow and fog. Zero weather is uncommon, and, in some places, rare along the southeastern coast. The result of precipitating the moisture on the seaward side of the mountains and of stopping the warm winds is to condemn all the country to the northward to a climate quite as cold as is to be found in other places in the same latitudes, and to a light rainfall of from about 10 to 16 inches annually. The climate, however, south of the Arctic Range, is far from being so cold and forbidding as is usually supposed. The temperature varies from about 90 degrees above to 70 degrees, perhaps a little more, below zero, but the air is dry and there is but little wind. Along the Bering Sea coast and in Seward Peninsula, however, the climate is raw as well as cold, and very disagreeable.

The climate of the country around Cook Inlet is midway between that of the south coast and the interior. The winters are quite cold and the summers warm, with from 25 to 40 inches of rainfall, and many sunny days. The climate is very similar to that around the Gulf of Bothnia in northern Europe.

North of the Arctic Range is a true Arctic waste, but little visited except by fur traders and missionaries.

The resources of Alaska are quite varied, but the most valuable are the minerals, fisheries, and furs. The Arctic slope and the Bering Sea islands produce great quantities of valuable furs, but have no resources requiring the construction of roads. The fisheries of the Pacific and Bering Sea coasts are similarly situated. The lumber and stone products of the southeast have as yet called for no roads, which is also true of a large proportion of the mines along the coast. Nearly all road work so far done has been called for directly or indirectly by the development of mineral resources, mostly gold.

The principal mineral resources are placer and quartz gold, copper and coal. Gold is widely scattered, and up to the present time has been by far the most important. Copper is found mostly on the Pacific Coast and to the eastward of the Copper River. Coal is found in many places, but the most valuable deposits are in the Bering River and the Matanuska fields. Other minerals are found in considerable quantities, and agriculture has developed somewhat near the mines and in the south and southeast.

The permanent white population is between 30,000 and 40,000—nearly all in the neighborhood of the mines or on the routes of travel thereto. The principal gold mining centers are Juneau, Fairbanks, Nome and the Iditarod River. To reach these places from the coast or rivers, and to reach from them out to the mines, most of the roads in Alaska have been built, although many roads have been built to and from other places.

Alaska is provided with a very good system of natural waterways. The Pacific Coast harbors are open the year round, except the northern end of Cook Inlet. Fogs and snow, however, make travel rather dangerous in winter. The mouth of the Yukon is closed to navigation about nine months of the year, and the Kuskokwim eight months. The Kuskokwim is navigable to above the Forks, and the Yukon to within 110 miles by rail from Skagway. The more important branches of the Yukon, as the Tanana, Koyukuk and the Innoko, are navigable for considerable distances. The Susitna, Kobuk, and other rivers are also navigable but have much less importance than the Yukon or Kuskokwim.

In addition to the rivers there are now railroads to some of the mining towns near Nome and Fairbanks, and from the coast at Seward to Turnagain Arm, and from Cordova through the Coast Range by way of the gorge of the Copper River to the copper mines along the Nizina River. The White Pass Railroad from Skagway to Whitehorse, connecting with river steamers on the Yukon River, is one of the main highways of the North.

Up to the time of the discovery of gold on the Klondike River, a tributary of the Yukon a short distance east of the boundary line between Alaska and Canada, in 1896, the population of Alaska and the adjacent Canadian territory was too sparse to call for any construction of artificial means of communication. The methods of communication at that time were practically as they had always been before the appearance of the white man—by canoe on the rivers in summer and by dog-sled in winter. The only improvement having been the use of steamboats to a limited extent on the larger streams and along the coast. The use of the reindeer, so common in northern Europe and Asia, had never extended across Bering Straits. Reindeer have since been introduced in Alaska but are little used as yet for transportation, dogs being preferred in places where horses can not be used.

In the great interior of the country away from the rivers, there was but little travel in summer, due to the extreme difficulty of getting across the tundra. Travel on land in winter, away from beaten lines, was and still is preferred, as the snow and ice make fairly good footing under ordinary conditions.

The Russians confined their activities mostly to the Pacific and Bering Sea coasts and to the lower parts of the rivers emptying therein. The Hudson Bay Company had trading posts in Canada and extending down the Yukon River as far as Fort Yukon, at the mouth of the Porcupine River. Their supplies were carried overland by canoe and dog-sled from York Factory on Hudson Bay. The rest of the interior was very little known. The upper Yukon was supposed to flow into the Arctic Ocean until the parties surveying for the Russian-American Telegraph Company made the trip by water from Nulato to Fort Yukon in 1866.

For long after the United States acquired the territory progress was very slow. The Hudson Bay Company abandoned Fort Yukon and withdrew to Rampart House on the Porcupine River just across the boundary, and most of the Russians left for Russia.

The seal fisheries were developed and, to some extent, the salmon and other fisheries on the coast; and fur trading was taken up by American companies. Gold was discovered in the neighborhood of what afterward became the city of Juneau, the capital of the territory, resulting in the famous Treadwell and other mines.

Finally, gold was discovered in the early eighties along Fortymile River, a tributary of the Yukon just across the boundary from Canada, and the first feeble settlement other than fur traders and missionaries in the interior began. Later gold was found near what is now Circle City, and near Turnagain Arm in southwestern Alaska in 1895. Traces of gold had been found in the latter place about fifty years before, but no mining had been done.

The great gold rush to the Klondike in 1896-1898 began to attract men to the northland and began the real period of development. Since then there have been setbacks, but the territory has as a whole gone forward to a remarkable extent. Placer gold was later found at Fairbanks, at Nome, along the Iditarod River and at numerous other places. The development of the very valuable fisheries of the coast and the opening up of copper and quartz gold mines has put the country on a permanent basis of prosperity—placer gold, as in California and other places merely serving to bring men to the country, its prosperity depending on the development of resources requiring more time and labor and not so easily exhausted.

At the time of the Klondike rush, the easiest way to the upper Yukon Valley was, and still is, by way of the Chilkoot and White passes. A longer route, though better in winter, was by the Chilkat Pass. All these passes are near the head of Lynn Canal. Much longer and thoroughly impracticable routes, dictated largely by what might be called fake patriotism, were the ''All Canadian Route,'' through Edmonton, and the ''All American Route'' through Valdez.

The construction of the White Pass Railroad, which soon followed, and of the railroad to the mines near Dawson, gave valuable experience and models to the engineers later engaged on similar work in Alaska. The wagon and sled roads to and from Dawson were valuable guides for the earlier construction across the boundary line. These constructions were the first of their kind ever built under semi-arctic conditions, and, together with later constructions of the same kind in the Canadian Yukon and Alaska, are, it is believed, the only ones in existence up to the present time.

Various explorations were made in Alaska from time to time by the Army, but no thought of, in fact, no necessity for, improvements in communications existed until after the Klondike discovery referred to above. In 1898-1899, a military expedition in charge of Capt. W. R. Abercrombie, Second Infantry, was sent out from Prince William Sound and vicinity to explore the country and locate in a general way lines of travel to the interior. One of the parties located a route from Valdez over Thompson Pass, which has since become the chief overland route to the interior.

In 1900 Congress appropriated $100,000 for roads and trails, with which Captain Abercrombie constructed a pack trail into the Copper River and Tanana River valleys in 1900-1901. This route was available for wagons for a short distance out from Valdez and in parts of the Copper River Valley and, with difficulty for single-horse, double-ender sleds, and pack horses throughout its length. Bridges were built across the worst streams, and swampy places were corduroyed; but the work was, from lack of funds and suitable transportation, quite limited.

The two most important bridges, over the Tonsina and Klutina rivers, are of considerable interest as an illustration of what can be done in case of necessity, and of the ingenuity of the American frontiersman. The Klutina River, where the bridge was built, had an island in the middle of the channel, and required two bridges about 140 feet long. The Tonsina River required a bridge about 175 feet long.

The foreman was given a crew of eighteen men, a few axes, saws, augers, adzes, a little rope and nothing more except food for the men. No horses or mules could be had, and no iron nor metal of any kind. The material available was the scrubby and rather weak spruce of the interior and boulders in the stream bed to fill in the pier cribs.

Six 56-foot king-post trusses were built. The piers consisted of timber cribs pinned together with wooden pegs and filled with man-size stones, and resting on the bed of the river. The trusses were of wood, hewn roughly into shape and held together with wooden pegs. The floor was of poles adzed off a little on top and held in place by other poles pegged to the stringers.

The bridges were built in an incredibly short time, considering the difficulties and means available. The Tonsina bridge—two 56-foot spans and 175 feet long, including approaches—was, as I recall, built in three weeks time. The Klutina bridge—four spans and 275 feet total length—took about twice as long. With the construction of the sled, and later, wagon road these bridges have carried a great deal of heavy traffic, two and four-horse loads, for years with very few repairs. The Klutina bridge was replaced in 1911, after eleven years service, and the Tonsina bridge is still in use after thirteen years service. The latter is to be replaced this winter by a bridge built of Oregon fir brought from the "States," 1,700 miles by water and 90 miles by sled or wagon.

The whole trail has been of great benefit from the start, and some short stretches in the Copper River Valley are still used as a wagon road, having required but little extra work to put them in shape.

In 1904, Congress appropriated money for a survey for a wagon road from Valdez to Eagle, and for surveys from the Yukon River to the Koyukuk mining fields under the Engineer Department of the Army. No construction work was authorized, and nothing further was done on these particular routes.

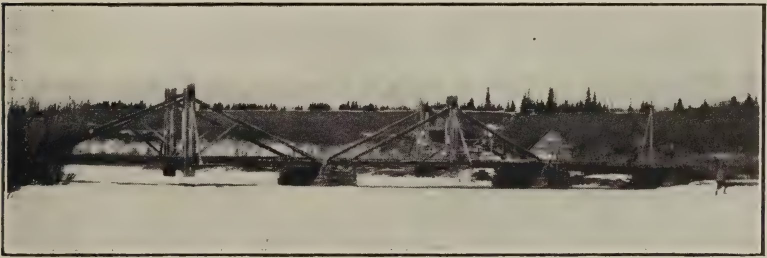


Fig. 1. Klutina Bridge, Valdez-Fairbanks Road. March, 1910.

In 1904 a road tax law was passed requiring all able-bodied men between 18 and 50 years of age, residing outside incorporated towns, to work two days each year on the public roads, or furnish a substitute, or pay $8.00 in money. Until later, when taken up in cooperation with the Alaska Road Commission, little was accomplished under this law. Usually it was not enforced, and when it was the money and work was largely wasted. Where money has been collected and spent in conjunction with the work of the Road Commission, considerable benefit has been accomplished. The work done under this law to date would have cost, probably, from $125,000 to $150,000 if done from direct appropriations.

Some work has been done from time to time by private subscriptions, principally at Nome, Fairbanks, and Cordova. This work has usually been done under the direction of the Road Commission.

The real beginning of systematic road and trail construction in Alaska dates from the organization of the ''Board of Road Commissioners for Alaska,'' usually called the ''Alaska Road Commission,'' or locally the ''Road Commission,'' in 1905. Prior to that time the only artificial means of land communication were the pack trail from Valdez—heretofore described—a short piece of road from Juneau back to what is known as ''The Basin,'' built by private subscriptions, a few roads built by miners around Fairbanks, and a few winter trails.

The Road Commission was organized in the spring of 1905, pursuant to the following law:

An Act to provide for the construction and maintenance of roads, etc., in the District of Alaska.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That all moneys derived from and collected for liquor licenses, occupation or trade licenses, outside of the incorporated towns in the district of Alaska shall be deposited in the Treasury Department of the United States, there to remain as a separate and distinct fund, to be known as the ''Alaska fund,'' and to be wholly devoted to the purposes hereinafter stated in the district of Alaska. One-fourth of said fund, or so much thereof as may be necessary, shall be devoted to the establishment and maintenance of public schools in said district; five per centum of said fund shall be devoted to the care and maintenance of insane persons in said district, or so much of said five per centum as may be needed, and all the residue of said fund shall be devoted to the construction and maintenance of wagon roads, bridges, and trails in said district.

Sec. 2. That there shall be a Board of Road Commissioners in said district, to be composed of an Engineer officer of the United States Army, to be detailed and appointed by the Secretary of War, and two other officers of that part of the Army stationed in the said district and to be designated by the Secretary of War. The said Engineer officer shall, during the term of his said detail and appointment, abide in said district. The Board shall have the power, and it shall be their duty, upon their own motion or upon petition, to locate, lay out, construct, and maintain wagon roads and pack trails from any point on the navigable waters of said district to any town, mining or other industrial camp or settlement, between any such town, camps, or settlements therein, if in their judgment such roads or trails are needed and will be of permanent value for the development of the district; but no such road or trail shall be constructed to any town, camp or settlement which is wholly transitory or of no substantial importance for mining, trade, agricultural, or manufacturing purposes. The said Board shall prepare maps, plans, and specifications of every road or trail they may locate and lay out, and whenever more than five thousand dollars in the aggregate shall have to be expended on the construction of any road or trail, contract for the work shall be let by them to the lowest responsible bidder, upon sealed bids, after due notice, under rules and regulations to be prescribed by the Secretary of War. The Board may reject any bid if they deem the same unreasonably high or if they find that there is a combination among bidders. In case no responsible or reasonable bid can be secured, then the work may be carried on with material and men procured and hired by the Board. The Engineer officer of the Board shall in all cases supervise the work of construction and see that the same is properly performed. As soon as any road or trail laid out by the Board has been constructed and completed, they shall examine the same and make a full and detailed report of the work done on the same to the Secretary of War, and in such report they shall state whether the road or trail has been completed conformable to the maps, plans and specifications of the same. It shall be the duty of said Board, as far as practicable, to keep in proper repair all roads, trails constructed under their supervision, and the same rules as to the manner in which the work of repair shall be done, whether by contract or otherwise, shall govern as in the case of the original construction of the road or trail. The cost and expense of laying out, constructing and repairing such roads and trails shall be paid by the Secretary of the Treasury out of the road and trail portion of said "Alaska fund," upon vouchers approved and certified by said Board. The Secretary of the Treasury shall, at the end of each month, send by mail to each of the members of the Board a statement of the amount available of said "Alaska fund" for the construction and repair of roads and trails, and no greater liability for construction and repair shall at any time be incurred by said Board than the money available therefor at that time in said fund. The members of said Board shall in addition to their salaries, be entitled to receive their actual traveling expenses paid or incurred by them in the performance of their duty as members of the Board.

* * * * * * *

Approved January 27, 1905.

A few changes have since been made in the above law, a very important one being a change in that part requiring a contract for any road or trail costing more than $5,000 to more than $20,000 for any road or trail or section thereof. This change permits the Board to construct any road it may desire without contracting for it — a very essential authority under existing conditions.

The original board consisted of Maj. W. P. Richardson, Thirteenth Infantry, President of the Board, First Lieutenant G. B. Pillsbury, Corps of Engineers, Engineer Officer, and First Lieutenant S. C. Orchard, Third Infantry, Secretary and Disbursing Officer. The engineer officer has since been changed twice and the disbursing officer once. Headquarters were established at Skagway, but were afterwards moved to Valdez when work on the Valdez-Fairbanks route began to assume its great importance. The duties of the board, partly in compliance with the law, partly through an understanding of the desires of the War Department, and principally from necessity and the general experience and qualifications of its members, were divided roughly as follows: Matters of policy by the President; details of construction by the Engineer; Disbursements by the Secretary. The duties largely overlapped, and matters not specifically given to one member by law required the approval of a majority of the board. The disbursing officer spent his whole time at headquarters and looked after such field work as was in the vicinity thereof. The engineer spent the summer and part of the winter in the interior on inspection trips and looking after work. His inspections in southeastern Alaska and office work were done in the spring and fall. The president spent the summer in the interior, a short time in the spring and fall in the office and the winter in Washington, D. C. The president and engineer usually arranged to go separately, so as to get over as much territory as possible. The general question of where to build roads and what kind to build rested mostly with the president, though largely with the engineer, as they, on account of getting over the territory so much, knew conditions better than the disbursing officer.

The territory was divided into a number of districts, each under a superintendent who had charge of work in his district, kept the board informed as to general conditions in the territory within his jurisdiction, and made recommendations as to construction work necessary. Most of these superintendents were employed only during the working season, but at the more important points, viz, Valdez, Fairbanks, and, as a rule, Nome, the superintendents were employed and their sub-offices kept open the year round. Each superintendent was responsible for the work in his district; hired his own working parties and paid off his men; and, except in a few special cases, bought all supplies necessary. As a rule, roads were located by the superintendents or their assistants, although in some cases this work was done by the engineer officer himself or by some one specially designated by him. Supplies were, as a rule, bought by the superintendents in the local markets by circular proposals, or, in emergency, by oral agreement. In a few places in the interior an agreement was made with one of the large commercial companies to furnish supplies to the board at special rates. At Valdez the bulk of the supplies were bought by the disbursing officer after inviting bids from merchants in Valdez and Seattle. Special bridge material, tools and equipment were usually purchased in Seattle by the engineer officer.

Payments in the ''States'' and at headquarters were made by the disbursing officer in the usual way. In the matter of payments two difficulties immediately presented themselves. The rate of exchange in different parts of Alaska varies from one-half to one per cent on all checks for the ''Outside'' (''States'' or United States) regardless of what city they are on and whether Government or not. Special arrangements were made with banks and commercial companies wherever expenditures were to be expected, to cash checks at par, the board afterwards paying a rate of exchange previously agreed upon. As work was scattered all over the territory, often far from mail connections, to have attempted to make payments from headquarters would in most cases have required dealers and workmen to wait months for payment. It was arranged that each superintendent should make payments by check on a local bank or commercial company. The board paid exchange on these checks as described above, and checks to the value of these payments plus exchange were deposited in Seattle or San Francisco to the credit of the bank or company. The vouchers were sent to the disbursing officer who accounted for them as cash payments. These arrangements, of course, required special authority from the Secretary of War. Without them it would have been extremely difficult and expensive to get anything done. The question of depositing money in local banks to be drawn on by the superintendents instead of using the system adopted was considered, but abandoned as none of the banks was considered entirely safe. The superintendents were from necessity given a great deal of latitude in their work, as it was impossible for the president or engineer to inspect even the most important roads more than once or twice a year, and some of the less important could not be inspected more than once in two or three years. Roads were scattered from Prince of Wales Island to the Arctic Ocean and Bering Straits. Travel was by steamboat, canoes, horseback or on foot in summer, and by horse-sled, dog-sled, or snow-shoes in winter, and was often necessarily slow and difficult.

In addition to the funds provided for in the Act forming the board, which have amounted to an average of about $110,000 per year, special appropriations have been made by Congress each year since 1905. These appropriations varied in amount from year to year and were always uncertain. The amounts available from the Alaska fund could never be told in advance. Allotments for expenditure on different projects were made by the board on the recommendation of the superintendents and the advice of the engineer officer. They were usually made as early as possible in the spring after the special appropriation was allowed. Supplementary allotments were usually made later on, depending on the condition of the different works and the money available.

The different kinds of construction undertaken have been classified by the board under four general heads: Wagon roads, winter sled roads, trails, and staked trails. In this case the greater does not necessarily include the lesser. Wagon roads are not necessarily available as sled roads or even as trails under some winter conditions. The term "wagon road" is applied to roads intended for use by double teams and wagons carrying considerable loads the year round. They are given suitable grades and are crowned, ditched, drained, and corduroyed or planked where necessary. Winter sled roads are for use of double teams and sleds in winter. They are cleared and graded where necessary, but not surfaced or drained. Trails are of two kinds—for single-horse sleds, which differ from winter sled-roads only in width and in the care put in their construction, and pack trails. Staked trails are either temporarily staked each winter with poles or laths and cloth streamers, or permanently marked with iron stakes to point out the trails and keep people from getting lost in treeless and windy places where trails become quickly obliterated by the drifting snow.

The standard of wagon road adopted was a good earthen highway, planked or corduroyed where necessary. Although such roads are apt to become badly cut up in rainy weather or during the spring thaws if traffic is heavy, this was the most that the board felt justified in attempting on account of the vast extent of territory to be covered, the expense of construction, the very limited funds available, and, in most places, the limited traffic. At the best, it has been impossible, from lack of money, to build roads in many places where they are badly needed. In some cases the standard was departed from where traffic was exceptionally heavy or exceptionally light.

Nearly all work was done by day labor, as it was almost impossible in most cases to do it in any other way. Few men could be found who had the experience, money, and inclination to do the work by contract. On account of depending on taxes collected from time to time, and on uncertain appropriations, it was difficult to arrange for work in advance. The character of construction was such as to make it impossible, as a rule, to determine quantities and conditions with sufficient accuracy for a contract. On account of the shortness of the working season, the locating parties were often followed closely by the construction crews in order to do the work the same year.

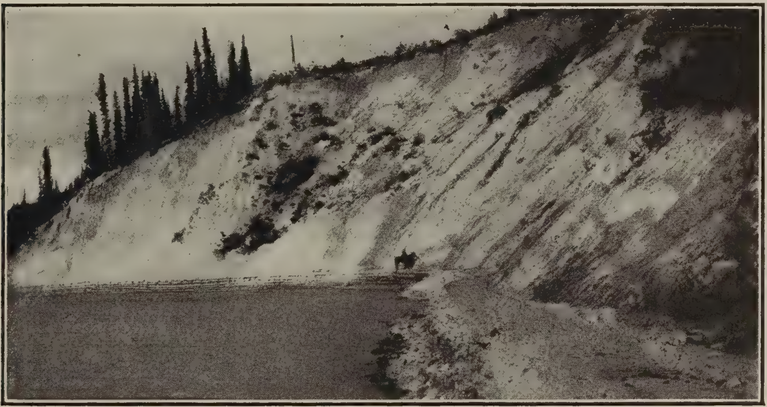


Fig. 2. Along Tonsina River; Valdez-Fairbanks Road.

The following general instructions were issued for guidance in location work:

WAGON ROADS.

2. The locator should most carefully cruise and examine the ground, covering all possible routes, select the best, and then proceed to lay out his line on the ground. Preliminary surveys will be made only in exceptional cases.

3. The first consideration must always be to select the line giving the cheapest road that will fulfill the purpose. Frozen or swampy ground must be particularly avoided. Side hill cuts on very steep slopes and lines involving considerable rock work will be avoided where possible. Deep cuts and fills will not be laid out.

4. *Grades.* The grades should be kept as low as possible, without making the road unnecessarily expensive. As a general proposition, however, it will be found that low grades involve heavy cost of construction, on account of either extensive grading or wet ground encountered. The maximum grades allowable will be used if by so doing the cost of construction will be reduced.

The following are the maximum grades:

Short grades, 100 feet or less in length, with easy grades at both ends, may be 15 per cent (9 degrees) if *straight* and with straight approaches.

Medium grades, 300 feet or less in length, with easy grades at both ends, may be 10 per cent (6 degrees) if there are no sharp curves either on the grade or approaches.

Long grades, over 300 feet in length, uphill for loaded wagons as freight is usually hauled, should be kept down to 6 per cent (3½ degrees) if possible, with reasonable expenditure. They may be as much as 8 per cent (5 degrees), but no more, if a less grade can not be obtained with reasonable expenditure.

For heavy traffic downhill, or for light traffic in general, the grade should be kept to 8 per cent, if possible with reasonable expenditure. It may be increased to 10 per cent, but no more, if a lower grade can not be constructed at a reasonable cost.

Grade lines should follow the natural slope of the ground, taking advantage of favoring benches, etc.

Grades should never be guessed at, but must be measured.

5. *Curves.* Sharp curves should be avoided if possible, but where they can not be avoided the line *must be level.* The minimum curvature is of 50-foot radius. Unless the radius is at least 100 feet, the maximum grades should not be used. Curves need be laid out only where the line crosses spurs or ravines, or at the approaches to bridges, or to sharp steep grades, etc. As a rule, in crossing small ravines, etc., it will be preferable to use a straight steep grade rather than a sharp curve.

As stated above, the line will in general follow the natural curve of the ground, without reference to tangents and circular curves.

6. In general, in addition to the above requirements, wagon roads should be laid out with a view to their winter use; that is, they should have proper protection against drifting snow. (Paragraph 10.) There are cases where, however, the wagon road will not be followed in winter, as, when winter travel will cross some level swamp; and in any event, the line for the wagon road

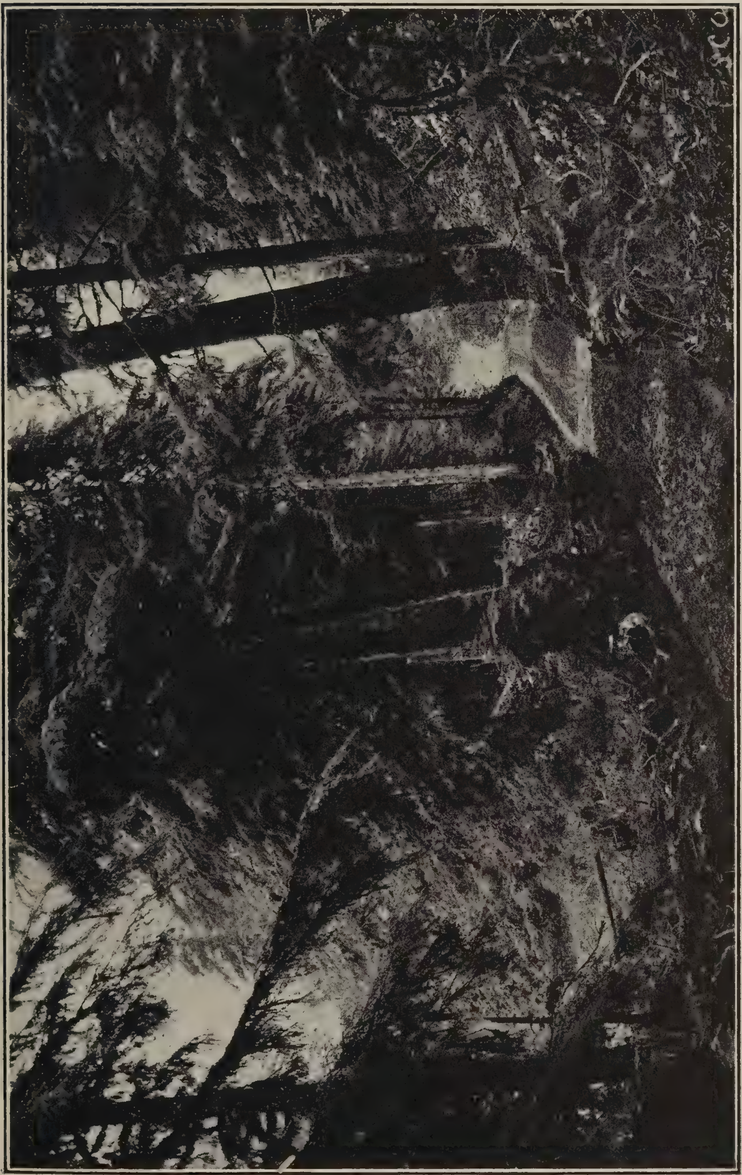


Fig. 3. Portage Road, Prince of Wales Island, 1907.

should not be placed on wet ground for considerable distances merely to fit it for winter travel.

7. *Marks.* The location of the line will be marked by stakes set every 100 feet, and mile-posts will be established at the end of each mile. Mile-posts should be measured from the generally accepted center of the town of departure.

8. *Record.* The Board is required by law to prepare maps of each road. To this end, the locator will take the necessary magnetic bearings and distances, with such side notes as may be necessary, and record them in such manner that they may be plotted without further explanation from him. At that point of beginning and at every 20 miles thereafter, he will make and record an observation to determine the variation of the compass.

SLED ROADS.

9. *Grades, etc.* The grades on sled roads will depend on the traffic, to a more considerable extent than on the wagon roads.

If the traffic is expected to be heavy enough to keep the trail well broken, the grades should be at least as low as the maximum specified in paragraph 4 for wagon roads, and *as much lower as possible.* Easy grades should never be sacrificed to put the line on dry ground.

If the traffic is expected to be light so that difficulty is to be anticipated on account of snow, the grade may be increased to as much as 15 per cent to keep out of drifts. This will be particularly applied in crossing divides, where the main line should be located as to cross with the least side-hill cutting possible.

10. The first requisite for sled roads is proper protection from wind and drifting snow. With this end in view, they should be located in timber if possible, but *never close to the edge of timber.* High bare ridges should be avoided, but the tops of such ridges are preferable to a location just below the crest of the slope. The foot of steep bare slopes is a particularly bad place for a sled trail.

11. While giving first attention to protection, at the same time as dry ground as can be had should be selected for the line.

12. The line of the sled road will be staked, not blazed, and mile-posts will be established. It is not necessary, however, to set the stakes at 100-foot intervals.

13. The located line will be surveyed and recorded by the locator, in the same manner as a wagon road (Paragraph 8), but with less detailed notes.

PACK TRAILS.

14. Pack trails should be laid out to secure dryness of ground, easy crossing of streams, and easy construction. Grades up to 25 per cent or 30 per cent may be freely introduced to gain these results. The location of pack trails will be recorded simply by general compass bearings and estimated distances.

These instructions were necessarily varied somewhat in special cases, and it was found that the best location for a wagon road was not often best for a sled road, and vice versa. Paragraph 6 was therefore changed accordingly. These instructions are given here complete, as they involve conditions not met with in the "States."

As conditions in southeastern Alaska are quite distinct from those in other parts of the territory, a brief description of the work in this section will be given separately.

The conditions do not vary greatly from those in some parts of the "States," the main difference being due to the extremely heavy rains. With few exceptions the whole country is heavily timbered and with dense underbrush. It is very hilly and rocky, with few level valleys or benches. Rains are excessive in summer and snow in winter. Wherever level country exists it is apt to be swampy, if not properly drained. The surface of the ground is usually covered with a thick layer of decaying vegetation, often several feet thick. However, supplies can be delivered by boat within a very few miles of any part of this whole district. Freight rates are rather high on account of dangers to navigation from fog or snow, but land transportation is over such short distances that the cost of transportation in general is not very serious on road work. Away from the roads, of course, the country is almost impassable, but this does not affect the cost of road construction greatly, although it increases largely the difficulty in preliminary surveys and location. Labor in general was paid about $2.50 per day with board. Although supplies and labor are much cheaper, owing to the great amount of work, the number of bridges to be put in, the cost of clearing and grubbing, and the excessive rains, road work in southeastern Alaska is, as a rule, the most expensive in the territory. Maintenance is also very expensive. To quote an example of the conditions under which work must be done here—in the summer of 1906, on a road on Prince of Wales Island, out of one hundred and twenty-six working days during the season, it rained hard one hundred days, with slight drizzle and cloudy ten more days, leaving but sixteen days of clear weather for work. Of course, under such conditions men work in the rain, but their efficiency is much reduced. There are but few features of the work in this district of interest, and a description of only a few roads will be given.

The Prince of Wales Island portage road referred to above is the most expensive road built in Alaska. It consists of 3.9 miles of wagon road and 7 miles of pack trail. The wagon road portion was cleared 24 feet wide. Corduroy and culverts were made 13 feet wide. It was finally found necessary to plank a very large portion of the road, the excessive rains making it almost impossible to retain any other kind of surface. Planks made from timber shipped from Seattle were found to be much cheaper than corduroy cut on the ground; this was partly due to the difficulty of getting timber of suitable size. The wagon road portion cost approximately $7,915 per mile, due to the extremely bad conditions already described. Rains were almost continuous throughout the working season. Timber cost $14.00 to $14.50 per thousand delivered on the shore at either end of the road. Corduroy cost $2.18 per foot. Planking, $1.26 per foot. Clearing, $700 per mile. Grubbing and grading in earth, $1,895 per mile. These costs are approximate only and do not include superintendence or surveying. Labor was about $2.50 per day with board. Supplies were purchased in Ketchikan and brought over in small launches. This road was advertised for contract in compliance with the law as it then was, but no bids were received and the work was consequently done by day labor.

The road up Chilkat Valley from Haines, known as the ''Haines-Pleasant Camp Road,'' was built partly by contract and partly by day labor. Its total length from Haines to the Canadian border is 47½ miles; total cost for construction was $119,953.71. The road follows the valley of the Chilkat River throughout its length. A great deal of rock work was required and some expensive bridges, but no unusual or unexpected difficulties were encountered in the construction. Conditions in every way were much more favorable than on the road previously described, as the rainfall is not so heavy at the head of Lynn Canal as in most places in southeastern Alaska. This road throughout a large part of its course was on level ground. The grades, as a rule, were very light.

The part connecting Haines with the Chilkat River at Hindestucki—3.04 miles—was advertised for contract, but as no bids were received it was built by day labor. It was graveled throughout and would compare favorably with the ordinary macadamized roads built in the more settled portions of the ''States.'' The remainder of the road is a specially good earthen road, although parts are graveled. Supplies were carried up the river and delivered at the various camps in war canoes with Chilkat Indian boatmen.

In general, the width of clearing through the timber was made 40 feet. The clearing was classed as heavy where the prevailing timber was spruce or cottonwood, and light where the prevailing timber was alder or brush. The roadway was graded to a width of 24 feet; all moss and decaying vegetation being removed from the surface, and stumps and roots being removed to a depth of 6 inches below the surface. Culverts were constructed where needed; they were built of sound spruce logs at least 6 inches in diameter at the smaller end, except floor logs which were allowed to be somewhat smaller. Abutments were made of log cribbing notched together with tie logs running into the embankment at least 5 feet, and the sill sunk deep into the ground to prevent undermining. Three stringers were placed with 5-foot centers. The width of the waterway was required to be at least 6 feet, and the height 3 feet. The flooring was constructed of poles or split logs at least 4 inches thick at the small end, hewed or adzed to a level surface. The width of culverts was 12 feet. Logs were placed over the outer stringers and pinned to them, each with two wooden pins 20 inches in diameter wedged in by drift bolts ⅝-inch in diameter. Many of these culverts were placed, but it was found that they usually became filled with solid ice during the

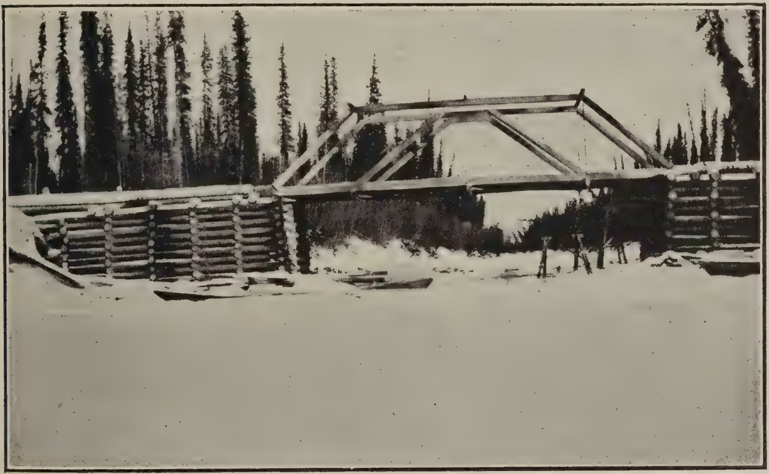


Fig. 4. Duggan Creek Bridge; Fairbanks-Fort Gibbon Sled Road, February, 1909.

winter and that unless the ice was chopped out in the spring before the thaw they would not be of much benefit.

Bridges were constructed where necessary across small streams. The abutments were built as for culverts. Piers were made of spruce log cribbing, triangular in plan, pointing against the current 18 feet in length and 8 feet in width at the larger end. The cribs were filled with rock. Stringers were of spruce, three in number, and of the following dimensions: Spans 10 to 15 feet wide, 10 inches middle diameter; spans 15 to 20 feet wide, 12 inches middle diameter; spans 20 to 25 feet wide, 14 inches middle diameter; spans 25 to 30 feet wide, 16 inches middle diameter. The flooring was the same as in culverts. This, of course, does not include the large truss bridges built over rivers.

On wet ground which could not be properly drained, corduroy was used. The corduroy was made of sound logs or poles not more than 10 inches in diameter and not less than 2 inches, and at least 12 feet in length. They were laid close together in one or two horizontal layers, depending upon the diameter of the poles, at right angles to the direction of the road, and covered with soil, not muck, from the ditches to a depth of 12 inches at the center and 6 inches at the sides. When, by reason of the scarcity of large trees, it was found necessary to use saplings of 2 or 4 inches diameter, the longitudinal layer was first placed upon the ground and the cross-wise layers placed upon top of this. Log cribbing retaining walls were built of spruce at least 6 inches in diameter at the tips. Face logs were laid in horizontal courses with a batter, depending upon the special conditions. Tie logs running at least 6 feet into the embankment were set at intervals of not to exceed 10 feet between every two courses. The top course was pinned to the top logs as for culverts. The height of cribbing was limited to 8 feet. In some cases plank was imported from the States and used in place of logs in bridge or culvert work.

The unit prices under the contract portion were (1908) as follows: Heavy clearing, per acre, $125.00; light clearing, per acre, $100.00; grubbing, per acre, $50.00; earth excavation, per cubic yard, 38 cents; rock excavation, per cubic yard, $1.00; corduroy, per linear foot, $1.00; cribbing, per linear foot, $1.50; bridges, per linear foot, $5.00; culverts, $10.00 each.

A bridge built across the Chilkat River at Wells consisted of two 108-foot trusses with approaches 100 and 300 feet in length.

No new or unusual difficulties presented themselves in its construction. Work was done by contract at a cost of $8,620.08. The material was brought from Seattle by boat to Haines and hauled up the road for a distance of 24 miles to Wells.

A foot suspension bridge built at Sitka is of interest chiefly because it was broken by tourists crowding on it and swinging it for amusement.

Other work done in this section of the territory presents but little of interest.

The roads constructed in southeastern Alaska are necessarily, on account of the country being cut up to such an extent, local roads; except the road in the Chilkat Valley from Haines, which, in conjunction with Canadian roads leading from its terminus, forms one of the main routes to the interior.

The main part of Alaska lying west of the 141st meridian contains the great mass of roads built by the board. It is also the part which differs most from other countries and in which most of the new and unforeseen conditions differing from those met with outside were encountered. Of course many things, such as the high cost of labor, freight and supplies, and some of the difficulties of transportation, exist in all frontier countries.

The conditions along the coastal strip differ but little from those in southeastern Alaska. Labor and supplies cost some more, but the work is the same. The only work of importance in this section is the coast portion of the Valdez-Fairbanks road, which will be described later.

Road work around Cook Inlet is, as a rule, the cheapest in Alaska, as the extreme conditions met with in the southeastern part and in the interior are lacking. There is no permanent frozen ground as in the interior, and the excessive rains common to the coast portion are lacking. A good deal of the country is fairly level; the underbrush is light, and while there is a fairly good stand of timber it is not as heavy as in the southeastern part. Where there is no timber a good growth of grass is usually found, except, of course, in the high mountains above the timber line. Kenai Peninsula is mountainous, but, as a rule, there are good passes for the construction of roads and trails. In the mountainous parts of this section travel during the spring thaw, or even in the winter, after a series of warm winds from the ocean, is apt to be dangerous on account of avalanches; the mountains being, as a rule, very steep, and the valleys quite narrow. The snow fall in the mountains is very heavy.

Supplies are brought to Seward by boat the year round or to the trading posts on Cook Inlet or Susitna River in summer. They are usually distributed by sled in winter. Travel in summer is usually on foot and sometimes horseback, and in winter by dog-sled or snow shoes. Freight, when hauled in summer, is usually taken in with pack horses. A number of roads and trails have been constructed, but they offered no special difficulty.

On the Moose Pass sled road, constructed in the Kenai Peninsula, grubbing and clearing cost about $137 per acre; side hill grading 40 cents per yard, or about $1,300 per mile; corduroy from 50 cents to 80 cents per foot. The width of the road was 8 feet. This cost was about the lowest in the whole country.

A number of roads and trails have been constructed from Cook Inlet, Seward, and the Alaska-Northern Railroad toward the interior, and to different mining camps in the vicinity. These, however, will not be described, as they offered nothing particularly difficult or unusual in their construction.

One of the main roads to the interior leads from the end of the Alaska-Northern Railroad through Knik, Susitna, Rainy Pass, and the mining camps on the Iditarod River. As most of this route lies in the interior, it will be described later.

In all that part of the ‘‘North Country’’ to the north of the Coast Range conditions are in some ways similar, or, to be more accurate, I should say that although they differ widely in different sections, these differences are so small compared with the difference between what one finds in any one section and what one is accustomed to on the ‘‘outside,’’ that they appear very similar. It is in this district that the conditions peculiar to an Arctic or semi-Arctic climate are met with. The climate becomes gradually colder to the northward and more raw to the westward, but there is no decided break like that met in crossing the Coast Range. Probably almost any equal area within the ‘‘States’’ would show as great a diversity.

Traveling in the cold in the North, while not by any means pleasant, is very far from being accompanied by the extreme hardships and danger which one is led to believe in from the harrowing tales of would-be ‘‘heroes,’’ told for the edification of their friends or for publication in the newspapers. With proper clothing and food there is little danger if reasonable precautions are taken. The sufferings, sometimes resulting in death even, of Polar expeditions are almost invariably due to starvation or improper food on account of getting so far away from their base of supplies. Of course, accidents are more apt to occur where the ground is covered with snow or ice than on solid ground, but to travel an equal distance away from your base, even in a temperate climate, if absolutely dependent for food and fuel on that base, would be difficult and dangerous. If properly clothed and fed almost any degree of cold can be endured if there is no wind. I have suffered much more from cold at a temperature of 10 degrees below zero with a light breeze blowing off of the Valdez glacier than from 63 degrees below in the interior with no wind. The chief difficulty below —50 degrees is in breathing the cold air. The sensation at —60 degrees is a good deal like that in breathing the rarified air at an elevation of 14,000 feet. These extreme temperatures are rather uncommon, although the temperature sometimes drops to —70 degrees or lower. Below —50 degrees the difficulty in breathing makes it troublesome to move rapidly or to keep warm by violent exercise. Personally, I should prefer traveling in winter to enduring the mosquitoes and gnats and wading through the tundra in summer.

Food should be rich in carbon and plentiful, as appetites are enormous. For a trip bacon, hot cakes and syrup and beans are best, particularly the first two, as no other kind of food appears to have so great a sustaining power. Tea is carried partly because it is lighter and easier to make than coffee, but particularly because it is much better for prolonged exertion, especially in the cold. To drink alcoholic stimulants either before starting or while on a trip is simply to commit suicide, as no man is strong enough to resist both the cold and liquor at the same time. The hardest drinker in the north would about as soon take poison as alcohol under such conditions.

Clothing in winter has to be carefully regulated. Too much clothing will make one perspire and then freeze almost as quickly as too little, if exercising. Bathing should be fairly frequent if possible, to keep the pores of the skin open, thus helping the natural heat of the body to keep the surface warm. The face should be kept shaven, as otherwise ice from the moisture in the breath will form on the beard and freeze the face. The following is a list of the clothes I wore in winter, which is a fairly good guide, although the requirements of different people differ and each must judge for himself: underwear of medium weight wool; flannel shirt, service or equivalent; medium weight winter suit; if on foot, mackinaw shirt instead of coat and vest; light khaki trousers as overalls; fur cap with silk top, as solid fur is too warm; heavy woolen mittens or gloves with leather mittens or gloves on the outside to break the wind; three pairs woolen socks, medium weight, next the foot, outside of these an extremely heavy pair, outside these a still heavier pair of German socks; moccasins, or, if riding, felt shoes with overshoes; if riding, a fur overcoat, otherwise a parki of khaki cloth with fur-lined hood. Fur should be wolverine, as it is the only kind that will not collect moisture from the breath and freeze. A parki is practically a large shirt worn outside the trousers and extending to the knees, as a wind shield. For some distance back from the Bering Sea and north of the Arctic mountains, where the climate is more raw and penetrating, fur parkis are used. Stiff collars and leather shoes are never worn except in town. Moccasins should be provided with a stiff sole, unless one is accustomed to them, as the arch of the foot, ordinarily supported by the sole of a leather shoe, will otherwise soon give way and become very painful on a rough trail. Colored glasses should be carried to protect the eyes from the glare of sunlight reflected from the snow.

Summer clothing is light, as the summers are fairly warm. I wore canvas, service leggings to protect my trousers from the underbrush and to keep out mosquitoes, and leather gloves to protect the hands from mosquitoes and gnats. After many experiments, I finally adopted the Quartermaster Department marching shoe issued in 1908, the best shoe I have ever found for walking under all sorts of conditions. Head nets *must* always be worn to protect against mosquitoes. They should be black in front, as other colors reflect the light and interfere with the vision. The number, size, and persistency of Alaskan mosquitoes exceeds anything I ever saw in a temperate or tropical swamp. They appear as soon as even a small patch of ground becomes bare of snow in the spring and they are found in undiminished numbers from the Coast Range to the Arctic Ocean. Gnats are, if possible, more troublesome in places, but they appear only for a short time in the fall.

A large proportion of the interior is broken and rugged. The valleys and level portions have usually a dense underbrush.

Where the ground is frozen, scrubby spruce timber prevails; where not frozen, birch and poplar. Most of Seward Peninsula is treeless and there is little timber outside of the river valleys. The ground, as a rule, is permanently frozen to a great and unknown depth, the surface being protected from thawing in summer by a thick blanket of moss or turf—the "tundra" of Siberia and the North generally. On account of this freezing, water from melting snow and rain is prevented from sinking, and, the evaporation being slight, any level ground is quite sure to be covered with water or shallow swamp in summer. Aside from this, the moss blanket prevents thawing more than a few inches in the brief summer. Cutting up this layer with wheels or horse hoofs lets in warm air and rain and, melting the ice, quickly forms an impassable quagmire. Travel over the tundra is, at best, difficult, and over the level and swampy places described above, almost impossible. For these reasons most travel, except on the rivers and where roads have been built, is in winter. Supplies are carried in summer by boat to the different places along the rivers and thence, as a rule, by sled in winter to their destination. The ice on the rivers is generally used when possible for travel where sled roads have not been built, and, on account of the easy grade, often for freighting where roads have been built. However, the ice is apt to be broken and rough, the open river is often swept by winds, and the fre-

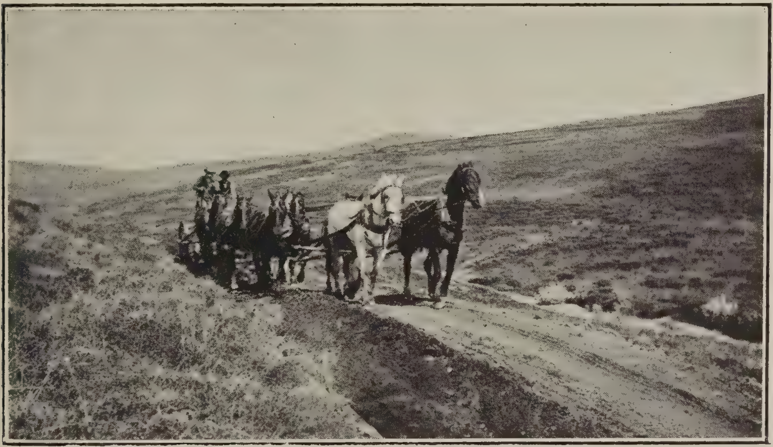


Fig. 5. Grader at work on local road near Nome, July 14, 1909.

quency of open water makes river travel dangerous. Travelers and mail carriers always, and freighters usually, will use a poor road rather than the river.

Open water, often met with, is very dangerous. To get wet away from camp and without a change of clothing is to freeze to death. For this reason, the one indispensable thing that must be carried is extra socks. Other articles may be necessary for comfort, cleanliness, or common decency, but the extra socks are often the price of a man's life. Just why open water should be found in the very coldest weather is not clear. Of course, warm springs exist in places, but this does not explain why water should appear in some places only in the coldest weather. A possible explanation is that when a stream freezes solid in places clear down to the frozen subsoil, the line of least resistance for any water flowing along the bottom is up through the ice, which cracks under the hydrostatic pressure and lets the water through.

Mules are never used, as their small hoofs cut through the snow in winter and the tundra in summer. Large horses are used, even for packing, as the cost of feeding them is but slightly greater than for small horses, and they can do so much more work. Dogs are used only where horses can not be. They are indispensable away from the beaten trails. The native Malamutes and Huskies and the Siberian Wolf Hounds are, for most purposes, the best, as being natives of the North they know how to take care of themselves. They are, however, part wolf and very treacherous, the wolfish nature asserting itself at times. Snowshoes are, of course, used where the snow is too light to carry one otherwise. The snowshoes used in the interior are much larger than those used on the coast, as the snow is light and powdery. Skis are used to a limited extent where there is a crust or a beaten trail for speed, or comfort, or sport. Below —50 degrees the snow does not soften readily under the friction of the runners of a sled so as to let it slip along, as it does under warmer temperatures. The sled grates and slides along much as though going over sand, making traction much heavier. This and the difficulty of breathing, before referred to, make travel slow at low temperatures.

The scale of wages for common labor was, with a few exceptions, as follows: In the Valdez district, which included the basin of the Copper River and the Valdez-Fairbanks Road at first to the summit of the Alaskan Mountains and later to the

Tanana River, $3.50 per day, less the cost of the provisions at Valdez—about 50 cents per day. This included the time going to and from Valdez. In the interior and on the Bering Sea coast, except around Nome, $5.00 per day and board. This sometimes included the time going to the place of work and sometimes not, depending on the circumstances. Provisions at the bases of supply along the navigable rivers cost roughly from $1.00 to $1.20 per day more. Around Nome, $4.00 per day and board. Provisions were not much more expensive at Nome than at Valdez. Labor, as may be seen, was expensive, but very efficient, as weaklings do not thrive in the North.

Game, particularly moose and caribou, and fish, particularly salmon, were plentiful, and some working parties had regular hunters and depended entirely on them for meats. The cost of all kinds of supplies and equipment was high on account of the freight rates. There is little rain, and daylight lasts for twenty-four hours throughout most of the working season. A common practice is to call base ball games at midnight, as such announcements look very attractive and impressive in the home newspapers.

The equipment used was usually such as might be expected for building a road by hand, supplemented in a few places by horse graders. Mosquito tents were used for sleeping. These tents had a canvas floor continuous with the rest of the tent, forming what was really a canvas sack with holes covered by mosquito bar for ventilation. Men lived quite comfortably in canvas tents, even in the coldest weather. Under such conditions, they usually slept in sleeping bags made of canvas or similar material lined on the inside with wool or fur, or preferably eiderdown, on account of its warmth and lightness. If caught out in the open at night one should keep moving unless a fire can be built. In case of need, it is possible to sleep fairly comfortably by burrowing into the snow and sleeping in sleeping bags.

The greatest expense of road building, aside from the high cost of labor, teams and supplies, is the permanently frozen ground heretofore referred to. A layer of moss is often found covering great masses of solid ice, locally called glaciers. Nearly all the bottom land and lower slopes of the valleys is frozen, and a large portion of the higher slopes. The frozen ground varies in composition. In the Tanana Valley it is mostly mica schist; in the Seward Peninsula a peaty muck. Where the soil is gravelly it can be stripped and graded as usual and, in many other places good roads can be constructed by stripping the moss, allowing the ground to thaw and afterward grading it. Of course, side-hill slopes and ditches slide badly when first exposed to the sun, but this stops after a while. Where the ground is such that it will not form a good road even after grading, corduroy must be used. In this case it is best to leave the protecting blanket of vegetable matter so as to prevent the ground underneath thawing. Fortunately, where the ground is frozen the timber which grows on it has no tap-roots but grows on the surface above the ice, it can be easily removed. In fact, it often happens that a fire burning out the moss will leave the roots of trees unprotected so that a very light wind will cause them to fall over. Trees should be grubbed out of the road bed and any hummocks of moss leveled off. A layer of poles is placed a foot or more apart, laid lengthwise to the road, the larger trees are used with the stiff branches cut off. Similar poles are then laid transversely to the road. Stiff branches are cut off, but the smaller branches are left. The corduroy is then covered with earth from the ditches to protect it from wear and to afford a smooth roadway. Moss or turf should not be put on the corduroy. As timber decays very slowly, this corduroy will last for a good many years. In the Seward Peninsula there is but little timber suitable for corduroy. Such roads are there very expensive. In some cases gravel is used, but it is often quickly beaten down into the muck underneath. An example of roads constructed under such conditions will be given in the description of a Nome local road.

Ditches, as a rule, must be wide and of gentle slope, otherwise they will wash and cut up badly, particularly in cases where the ground is nearly clear ice. In some instances ditches have cut clear under the corduroy and melting out pieces of solid ice have left considerable holes under the roadway. To prevent this a wide berm should be left. Where a road can be constructed along the bank of a river or small stream good under-drainage is provided; the only difficulty is in case the water should cut into the banks and destroy the road, as often happens. In any case, culverts should be provided not over 300 feet apart.

Culverts were constructed of logs and poles, except in the treeless parts of the Seward Peninsula and near the coast, where sawed lumber was cheaper. Culverts made of stone were used in a few places.

The long sled roads and trails connecting the different communities with each other and the outside world during the closed season (when the rivers are frozen up) are among the most valuable constructions made, although, of course, very much cheaper than wagon roads. The objections to using the surface of frozen rivers have already been given. The main requirement for a sled road is an easy grade. Protection from wind must be obtained if possible, both on account of the danger to exposure to wind in cold weather and on account of drifting snow. They should usually be put in the timber where possible, but never near the edge nor along the top of a ridge, nor along the side hills or the bottom of slopes on account of drifts. The best location is along a fairly flat timbered valley. Another element which it is practically impossible to foresee is the accumulations of ice, called ''glaciers'' that are built up during the winter, sometimes to a height of several feet by springs along the road. Sled roads can often be led directly across a pond or lake. In fact, one of the most important sled routes in the North crosses the upper end of Norton Bay and Golofnin Bay at considerable distance from land. However, such places and swampy land should be avoided if possible, as there is always a short period after the close of navigation in the fall before the freeze-up, and again in the spring after thawing begins, before the rivers are open to navigation. The hauling of supplies for parties working on the roads and for the road-houses along them, which are necessary stopping places for travellers, make it desirable to use good ground if possible.

The requirements for sled trail construction are very similar to those for sled roads, although not so strict. The same may be said of pack trails as compared with wagon roads.

The temporary staking of trails is done as heretofore stated, merely to mark the way to keep people from getting lost. A great deal of this was done, particularly in the Seward Peninsula. Poles or laths were usually stuck in the ground each winter, about 100 feet apart, with streamers of red cloth. Staking with permanent iron stakes was done for the same reason, but upon trails that were much more used. At first an iron pipe was used with an iron flag riveted or welded to it, but it was found that this flag would break off in a short time, due to flapping in the wind. For this reason, on later work of this kind, the flag was fixed so that it would revolve around the rod or pipe. This method worked very well, although it was somewhat more expensive than the previous one.

Bridges were usually made of native timber hewn into shape near the place of construction, or bought at sawmills, a few of which exist in the territory. Near the coast, bridges were sometimes constructed of wood or steel brought from the ''States.'' It was my experience that the wood found in Alaska was about two-thirds as strong as wood from the same species of tree in the ''States.''

Surveying encountered no special difficulties, except that due to the extreme difficulty of getting over the ground. This work, as well as the construction of sled roads and trails, was often done in the fall, sometimes necessarily so; after ground was frozen so that it was possible to travel, but before the snow came. This had the disadvantage that there was no forage for the animals, as the very first frost seems to take all nutriment out of the grass in most places. However, it is not often that animals can be subsisted by foraging. In a few places around Cook Inlet and the Tanana and White River valleys horses can live on the vegetation the year round. Where it is possible to travel, surveying was usually done, as was construction work, in the summer. The route from Washburn to Donnelly, part of the Valdez-Fairbanks route, was surveyed in the middle of winter with the thermometer at times as low as 40 degrees below zero.

The wagon roads constructed, with a single exception—the Valdez-Fairbanks road—and the greater part of the sled roads and trails were in the nature of local roads leading from various coast or river towns to the mines in the interior, or from various central supply stations to the mines in the immediate vicinity.

No attempt will be made here even to name the many routes constructed in Alaska or even to describe all of the more important ones. A few among the more important will be briefly described, omitting so far as possible details common to all or common to work in the ''States.'' The general features existing in all parts of the territory have already been given.

The Fairbanks local roads are a system of wagon roads 72 miles in aggregate length, leading from Fairbanks to the mines in the vicinity. They cost an average of about $1,350 per mile in addition to the local road tax, not counting overhead charges.

Maintenance costs about 10 per cent per year. Traffic is fairly heavy and automobiles are used during a great deal of the year. Graders were largely used, which accounts for the comparatively low cost of construction. The annual saving to the mines in freight rates has exceeded the total cost of construction of these roads. A similar road from Circle to the neighboring mines, 34 miles in length, cost $68,000. Supplies were, however, a little more expensive. The work was nearly all on frozen ground, and in many places corduroy had to be used. Corduroy road 16 feet wide cost about $1.00 per foot. The same width of road, not corduroyed, cost about $1,500 per mile. There were no large bridges included. This road is connected with Fairbanks by sled road.

The Fairbanks-Fort Gibbon sled road, 160 miles in length, was mostly constructed in the fall of the year after the ground had frozen, owing to the great amount of wet ground to be traversed. Clearing was heavy. The cost was $58,440.98, or about $365.00 per mile. The road was cleared to a width of 16 feet and graded where necessary to a width of 8 feet. Bridges and culverts were 10 feet wide.

Sled trails are narrow, and less carefully constructed than sled roads, and the cost is correspondingly cheap, running from a few dollars to $61.00 per mile in the interior and to as high as $373.00 per mile near the Pacific Coast. Pack trails along the coast cost as high as $758.00 per mile in one place. Trails were made from 6 to 8 feet wide, depending on conditions.

The sled trail from Cook Inlet via Knik, Susitna and Rainy Pass has been referred to. The first reconnaissance was made in 1908, but no regular location or construction was done until November, 1910, after I left Alaska. It connects Kaltag on the Fairbanks-Nome mail route with Seward via Dishkaket, Iditarod, Tacotna, Big River, Rohn River, Rainy Pass, Happy River, Skwentna River, Susitna, Knik, Eagle River, Crow Creek Pass, Glacier Creek, Girdwood, and the Alaska Northern Railroad. It is already used considerably throughout its length, and a great deal in some portions. It is intended to save the people and eventually mail in the districts through which it goes, and also those west of Kaltag, from the necessity of following the long route through Fairbanks. The cost of the different sections varied from $40.00 to $373.00 per mile, the former being in the interior, the latter on the mountain and coast section.

The various roads in Seward Peninsula are built to connect the different mining camps with the coast and with each other, principally with Nome. The cost of construction and of maintenance varied greatly. On the uplands generally, the rock is near the surface and the ground unusually dry for Alaska. In this section I have seen a two-horse team haul a wagon which, with its load, would weigh from 3,000 to 3,500 pounds across country, as can often be done in the western States. While this is unusual even in the Seward Peninsula, I never saw it done in any other part of Alaska. Some of the upland roads cost as low as $500 per mile.

In the lowland and swampy sections the cost of construction and maintenance is very high. Corduroy is expensive, as it must be hauled in from the outside, and tundra fires are numerous and apt to burn the corduroy. The soil, being largely peat, will of itself burn in many places, often smouldering for many days, as rains are infrequent. The most important and most expensive of these roads and, for its length, the most important in Alaska, is the Nome-Bessie Road, 3.3 miles long. This road was constructed in 1906. The roadway was built 22 feet wide between ditches. The ditches were ploughed in the spring when the frost was 2 or 3 inches from the surface and the material thrown to the center, with Fresno scrapers and road machines. After the sun had thawed the ditches the road was regularly crowned to an elevation of from 1 to 2 feet above the surrounding country. Gravel having been found unsuitable, as it ground into the muck, great quantities of gunny sacks (Nome's supply of coal is brought in gunny sacks) were laid on the ground, forming a sort of mattress and the gravel placed on top of this. A great deal of corrugated iron, the result of a fire in Nome in 1905, was used in the same manner; but the iron worked out from under the gravel in places and became dangerous to traffic. Consequently, most of it was removed. Willows were used in a few places, but did not give as good bearing surface as the sacks and were not as cheap. This road gave excellent service up to 1912, when it was decided to build a gravel road with telford foundation. The cost of this work has not yet been reported. The following table, taken from the annual report of the board for 1912, should be of interest.

Year.		Expenditure.	Summer tonnage.	Saving to shipper by reducing rate from $10 to $5 per ton.
1906	Construction	$16,378.43	2,500	
1907	Repair and maintenance	2,406.08	3,000	$15,000.00
1908	Repair and maintenance	3,670.00	4,300	21,500.00
1909	Repair and maintenance	2,744.62	4,000	20,000.00
1910	Repair and maintenance	900.00	12,000	60,000.0
1911	Repair and maintenance	2,272.29	11,400	57,000.00
1912	Repair and maintenance	3,512.19	15,000	75,000.00
	Total	$31,883.61	52,200	$248,500.00

The cost included overhead charges. Winter tonnage has been large, but, of course, did not require or justify, in itself, the large expenditure.

The cost of surveys is hard to separate from the cost of construction in many cases for, as has been said, the construction crews often followed the surveyors very closely, sometimes in fact belonging to the same party, and it was not possible to keep the cost separate. The location and survey of the Donnelly-Washburn sled road, 55 miles, part of the Valdez-Fairbanks route, cost $4,572.77. The location and survey of the Fairbanks-Hot Springs sled road, 160 miles, cost $3,184.81. These are important routes and the cost of the surveys is almost as great as for wagon roads. On the Pacific Coast costs are very high, for the reasons already given.

The preliminary reconnaissance for the sled trail through Kaltag, Rainy Pass and Knik already described, cost $5,813.74, covering the total expense from Nome to Seward, a distance of about 750 miles. Part of the country traversed was unknown, and, as the work had to be done in winter on account of the impassable nature of the ground, quite an elaborate equipment had to be provided. Transportation was by dog sled.

The most important land route in Alaska is that from Valdez on Prince William Sound, an ice-free port the year round, to Fairbanks, the great mining center of the interior, on the Tanana River. From Fairbanks roads or trails connect with practically every town or mining camp of any importance north and west of the Alaskan Range below Eagle. The ordinary way of reaching Eagle and the Forty Mile mining district, which is connected with it by a sled road, is by way of Dawson; although the Yukon River to Circle makes fairly good traveling and Circle is connected by sled road with Fairbanks.

Nearly all winter travel and mail for the whole interior and Bering Sea and Arctic coasts follows this route, as does nearly all overland travel in summer.

The history of this road is one of gradual evolution. At first nothing but a passable winter trail was attempted. Later this was developed into a sled road, and in 1909 the actual construction of a wagon road was begun. By the summer of 1912 this roadway was in very good shape for wagon traffic throughout its length.

The length of the wagon road from Valdez to Fairbanks is 379.5 miles. The distance by sled road is about 25 miles shorter. The Willow Creek-Chitina branch is 49 miles, and the Donnelly-Washburn cut-off 55 miles, long. There are a number of short sled road cut-offs made to shorten the distance or to avoid parts of the road not best suited to winter travel. The Donnelly-Washburn cut-off was constructed in 1907 at a cost of $16,881.74, about $307.00 per mile, including the survey. Maintenance to 1912 was $3,188.11. The Willow Creek-Chitina Branch was started in 1910 to connect with the Copper River Railroad. I give here the general specifications for this road as a fair sample of good sled road construction.

WORK TO BE DONE.

The work to be done under these specifications consists in the construction of a winter sled road from Willow Creek Road House on the Valdez-Fairbanks wagon road to the town of Chitina on the Copper River, following the line laid out by the locating engineer.

Clearing and Grubbing. The roadway for 8 feet on either side of center line will be cleared of all trees, brush and logs, the same to be cut close to the ground. The roadway will be grubbed for a width of 5 feet on each side of the center line.

Grading. Where the ground slopes 1 foot in 10, or over, the roadway will be graded to a width of 10 feet, which width will be increased on turns.

Staking. In open flats stakes will be planted at intervals of not to exceed 100 feet on alternate sides of the trail. The stakes will be substantial poles at least 8 feet in length firmly planted in the ground.

Bridges and Culverts. Bridges and culverts will be constructed where necessary to give a smooth and even roadway. Culverts are to be given a width of 12 feet. Width of bridges will be 10 feet.

Five spruce stringers should be used in each span sufficiently strong to bear heavy four-horse loads. Decking should be not less than 5 inches in diameter at the small end. For spans over 15-feet, truss bridges should be constructed according to Alaska Road Commission's standard plans.

Corduroy. Corduroy will be used where necessary on mucky or marshy ground. The width of corduroy to be 10 feet.

Mile-Posts. Mile-posts to be set at each mile from the railroad station. They should be of squared or sawed timber or squared standing trees, at least 4 inches square, and will be marked with neat black figures 3 inches in height.

The road must be completed throughout the present season if possible, and any work required by these specifications may be cut down this year if necessary to the minimum required for double-ender sleds.

Seventeen miles of this road have since been converted into a wagon road by proper ditching and draining. The cost was, for sled road, $670 per mile; for wagon road, $1,132 per mile. The main road follows in general the route of the Abercrombie Trail and the Valdez-Eagle survey as far as Gulkana, although very little of the actual line previously laid out is now used. Prior to 1909, about $230,000 had been spent on this route. A large part of this should be charged against the wagon road, as a good deal of the expense was for work of use for a wagon road, and part of the remainder was in the nature of location and experiments. In the costs to be given later all of the above will be included.

The two most expensive pieces of work done before this time were the construction of a good road through Keystone Canyon near Valdez, and the Taslina bridge. The former was 1.6 miles long and almost entirely in rock. Work was done by contract. The cost, including superintendence, was approximately $21,000. Some of the unit prices were:

Excavation, per cubic yard	$1.15
Retaining walls, dry rubble, per cubic yard	3.50

The Taslina bridge was built in February-May, 1906. It may be well to state here that large bridge work was almost always done in winter. The thick ice takes the place of false works. As this was the first large piece of work done by the board, and is a good example of work done under frontier conditions, I quote here the report of the, then, Engineer officer, Captain (now Major) George B. Pillsbury, Corps of Engineers, together with a list prepared by him, afterward, showing the distribution of expenses:

THE TASLINA BRIDGE.

The Taslina River crosses the Valdez-Fairbanks and Eagle trail 110 miles from Valdez. It is a very rapid stream, from 300 to 400 feet wide, and, except in the early spring, unfordable. Until this season a frail ferry has been in operation during the summer, but several persons have been drowned, chiefly through accidents to the ferry. The rapid fluctuations of the stream make it problematical whether a substantial ferry could be maintained. The drift carried by the stream in flood would render it impossible to operate a ferry during such periods.

For these reasons the board determined on a bridge across this stream. The necessary funds became available in January. The construction party left Valdez February 16 and completed the work May 12. At that season the horses used on the work could not be taken out over the Coast Mountains, two men remaining to care for them and were also employed in laying guard rails, etc., and later in packing out the bedding, equipment, etc.

The work was under the immediate charge of Mr. Ingram; Mr. Lars Holland was employed as foreman of construction and a large part of the credit for the successful completion and excellent workmanship on the structure is due to him.

The bridge consists of two Howe truss spans of 108 feet, two king-post spans of 50 feet, and approaches, to a total length of 450 feet. The clear width is 10 feet.

The main trusses rest on pile bents, which are protected by rock-filled crib piers. These piers are 40 feet long and 12½ feet wide at the base and 30 feet long and 10 feet wide at the top, with pointed ends. The outer ends of the small trusses rest on similar smaller piers. The trusses are all constructed of hewn timber, the lower chords being built up of from four to six pieces, bolted and keyed together. The tension members of the king-post trusses are of wire rope from the old ferry cable.

The expense of construction was largely increased by the indifferent character of the timber available. By culling the best trees for a radius of 6 miles from the bridge, sufficient was found, but few pieces could be obtained larger than 10 by 10 inches, 20 feet long. As forage costs 18 cents per pound, the cost of getting out the timber was very high.

The freighting of the greater part of the material from Valdez to the site of the bridge was contracted for at 12¼ cents per pound, but as this rate was lower than was profitable under adverse conditions, and as these conditions occurred, the contractor threw up the contract; and while the agreement had been drawn so as to prevent financial loss to the Government, it was only by a considerable effort that the freight was gotten to the bridge before the snow disappeared. This statement is inserted to show the peculiar disadvantages of contract work of any kind let to the lowest bidder in a country in which the ordinary facilities for executing work are as lacking as they are in Alaska.

Detailed records of the distribution of labor were kept, but lack of time prevents the preparation of their summary for the report. The total cost of the bridge, including plant, was $19,434.43.

The unit costs, up to the time that the engineer officer of the board left the work, April 1, were as follows:

* * * * * * *

The experience with this structure indicates that, in view of the small size of the available timber, the spans of wooden bridges constructed in the interior should be limited to about 80 feet.

DISTRIBUTION OF EXPENSES, TASLINA BRIDGE.

Plant.			
Tools, at Valdez		$284.90	
Pile driver, at Valdez		1,080.75	
Horses		1,597.00	
Sleds and harness		574.47	
Camp outfit		247.10	
		$3,784.22	
Deduct horses charged Route 6		575.00	
			$3,209.22
Transportation material and crew to Bridge.			
Own teams, labor and forage (7½ tons at 11½ cents per pound)		$1,735.92	
Hired transportation (10½ tons at 12¼ cents to 25 cents per pound)		2,936.08	
Wages of crew en route		892.00	
			$5,564.00
Getting out timber (15,000 linear feet at 19 cents).			
Felling		$769.15	
Swamping		173.60	
Hauling, including forage of teams		1,911.12	
		$2,853.87	
Charged to piling	$301.92		
Charged to cribs	603.83		
Charged to trusses	1,234.64		
Charged to decking	713.48		
		$2,853.87	
Substructure.			
Cutting out ice for piers (five)		$267.35	
Thawing		168.65	

Brought forward			$8,773.22
Piling (150 piles at $7.82).			
Setting up driver, making frame, repairs, taking down and storing	$220.28		
Proportional cost timber	301.92		
Driving piles	406.29		
Cutting fuel	44.30		
Night fireman	200.30		
		$1,173.09	
Cribs (650 cubic yards at $5.72)			
Material, iron	$64.50		
Proportional cost timber	603.83		
Framing	416.21		
Filling, including forage of teams	890.67		
		$1,975.21	
Riprapping		136.73	
			$3,721.03
Trusses (two 108 feet and two 50 feet).			
Materials, iron, at Valdez	$499.22		
Proportional cost timber	1,234.64		
Hewing and whipsawing (5,280 lin.ft.at 16c.)	851.21		
Framing	533.50		
Erecting	160.10		
False work	41.90		
			3,320.57
Decking (4,500 square feet at 28 cents).			
Proportional cost timber	$713.48		
Hewing	342.60		
Laying	124.70		
Wheel guards	117.25		
			1,298.03
General.			
Miscellaneous material used in construction	$46.31		
Blacksmithing	390.58		
Cooking and camp	578.25		
Superintendence	1,306.44		
			2,321.58
Total			$19,434.43

It should be remembered that all supplies, material, and equipment, including the engine boiler, came from Seattle, 1,700 miles by sea to Valdez, and were then taken on single-horse sleds over a poor trail crossing the Coast Mountains, which extend far above the timber line, and finally delivered at Taslina, 110 miles from Valdez.

Beginning at Valdez, the first few miles of the road are on the terminal moraine of the Valdez glacier and subject to frequent washouts. An abandoned railroad grade is used part of the way. The road then follows Lowe River through Keystone Canyon to Wortmans, 19.5 miles from Valdez, and to about 2 miles beyond. This section is subject to heavy rains and snows and frequent washouts. All but the first 12 miles is really mountain road, although the grades are easy. The road then ascends by side hill grades, maximum slope 4 per cent, to Thompson Pass. It then descends to Ernestine, 45.5 miles. This is all heavy mountain work. The cost of construction of the 45.5 miles from Valdez was $2,431 per mile. From Ernestine to Willow Creek, 30 miles, the work was what might be called light mountain work. The cost was about $1,900 per mile. The Willow Creek-Gulkana section, 37 miles, was the cheapest on the whole route; the cost was about $1,000 per mile. This section is on the flat benches of the Copper River Valley, usually well drained and thawed ground. The prevailing timber is poplar.

Fig. 6. U. S. Mail, near Golovin, en route to St. Michael, March 5, 1909.

The Gulkana-Sourdough (22 miles) and Sourdough-165 Milepost (19 miles) sections follow the benches and gently rolling land along the Gulkana River. The ground was frozen practically the whole distance. The costs were about $2,000 and $1,500 per mile, respectively. They are fairly typical of road construction in the interior. It was found that a little corduroy was needed, as the ground if stripped and laid bare under the sun for a while and properly drained, would soon become solid enough to make a good road. This discovery was quite a relief, as I have rarely seen a more forbidding aspect and had feared that most of this stretch would have to be corduroyed. The conditions resulting from frozen ground have already been described. This merely appeared to be a more than usually hopeless case. The 165 Milepost-Delta River section, 40.5 miles, crosses the summit of the Alaskan Range, often called Delta Summit. This summit is perfectly flat, being the bed of an old lake. Except by watching the way the streams flow, one can not tell where the divide is. This was the most troublesome section of the whole road. It cost only about $1,500 per mile for what was done, but there appears to be no possible way to make the road safe and secure. In winter this section is by far the most dangerous on the whole road, due to the long stretch above timber line, lacking in any kind of fuel and entirely exposed to the wind; the scarcity of landmarks to guide one; the danger of open water; and the liability to sudden storms. Road-houses have been built as near the timber line as possible and stakes are set to mark the trail, but these are of little help in a blizzard. Men have been lost and frozen within 100 yards of a road-house. In good weather, this summit is extremely easy to cross. In summer the road suffers from floods washing out the loose gravel of the glacial moraine and the shores of the Delta River.

The Delta River-McCarty section, 75 miles, offered a great deal of difficulty in the southern portion owing to glacier streams and overflows of the Delta River. A good deal of reconstruction and repair work was necessary. One small stream near Miller's Road-house has washed out two bridges, the second one being supposed to meet almost any possible flood. Glacier streams are, however, subject to sudden and remarkable floods, and their beds are readily shifted. A third bridge has been constructed with a trestle 748 feet long with a single king-post truss 30 feet long. The width of the stream is about 30 feet. This bridge cost $7,798.39, of which nearly 50 per cent was for forage and freight on supplies. The cost of the whole section was about $1,790 per mile.

The section from McCarty to Fairbanks, 91 miles, is along the north side of Tanana River. The general conditions are typical of the Tanana Valley. Part of the ground was frozen, with scrubby spruce, or tundra alone; and part was thawed, with birch. Some side-hill work was done and some rock work, but most of the ground was fairly level. The cost was about $1,800 per mile.

The above costs include bridges, except the Taslina Bridge. The costs can not be given exactly, as it is difficult to separate construction and maintenance on work extended over several years with both going on at the same time. Overhead charges are included.

All streams are bridged except the Gulkana, Tanana and Salchaket Rivers and Piledriver Slough, all of which have trail bridges or rope ferries. A bridge consisting of two 150-foot Howe truss spans is to be built across the Gulkana River this year. This is a difficult stream, and a suspension bridge was considered at one time but found too expensive. An experimental rock-filled crib put in the river by the present engineer officer, First Lieut. G. E. Edgerton, Corps of Engineers, has stood the spring ice run, so it has been decided to build a truss bridge.

The standard type of truss bridge on this road, as elsewhere, was that of the Taslina Bridge, except that the length of span was reduced to 75 feet on account of the timber being short and not very strong. The standard required for the road was a good earthen highway, properly crowned, ditched, and graded at least 10 feet wide, the clearing being 16 feet wide. The Fairbanks end was built under the immediate supervision of the superintendent there. Supplies were sent up the Tanana River by boat, sometimes by sled, to different points along the river, and then carried where needed by wagon or pack-horse, depending on the condition of the roads.

Supplies for the Valdez end, except near Valdez, had to be carried by sled on account of the prohibitive cost of summer transportation. This required careful planning in advance. From the amount of work desired to be done the next year the number of crews needed was decided in the fall before. The following were the standard crews and equipment:

BRIDGE CREW.

Personnel.

1 foreman.
1 pile-driver engineer.
1 blacksmith.
1 teamster.
1 cook.
2 carpenters.
2 broad-axe men.
10 laborers.

Equipment.

4 or six horses.
Pile-driver.
Extra boiler and thawing points.
Carpenter tools, axes, ship augers, etc.
Camp outfit.
Sleds, depending upon conditions.

ROAD CREW.

Personnel.

1 foreman.
1 cook.
2 teamsters.
1 blacksmith.
22 laborers.

Equipment.

4, 6, or 8 horses.
Grader.
Drag.
Mattocks, axes, picks, shovels, etc.
Camp outfit.
2 wagons.

The thawing points are for melting the ice in the frozen ground by means of steam carried through a hose from the extra boiler.

The number of men and horses needed and the supplies and equipment for each crew were worked out in detail, and the supply point for each crew's summer work determined. The supplies and material, except bridge material and occasionally tools, were bought late in the fall by the disbursing officer after advertising in Valdez and Seattle. Bridge equipment and occasionally tools were bought by the engineer officer in Seattle at the same time. Also such sleds for transportation and horses as might be needed during the winter. These supplies were usually delivered at Valdez early in January. The latter part of January, when the days lengthened so that sledding could be done to advantage, the sledding crews were organized. Transportation was with double-ender, single-horse sleds. Bob sleds would ordinarily have been cheaper and easier on the trail, but on account of the great snowfall and drifts over Thompson Pass and consequent expense and uncertainty of keeping the trail open, double-ender sleds had to be used. Also over the Delta Summit, on account of sudden storms and danger of open water, it was not safe to attempt to use bob sleds. To have had enough sleds and horses to carry all equipment at once would have been too expensive and a system of relays one day apart was therefore used. The sleds would be loaded and taken as far as they could for a day and camp established and the sleds unloaded, then more trips back and forth until all supplies were hauled to this point; then another camp one day further on would be established in the same way, and so on. This was found much cheaper than to attempt to haul things straight through. Freight would be stored in various caches along the road. A cache might be defined as a depot where supplies are stored for safe keeping. For safety, these caches were put either near a telegraph station or a road-house; the keys were delivered to the telegraph operator (a Signal Corps soldier), or to the road-house keeper. When the freighting was completed, bridge crews would be left to do their work before spring and the remainder of the men, with horses and sleds, taken back to Valdez. Owing to the great cost of transportation only the very best of all kinds of supplies were bought. Grain was double-sacked to prevent loss; hay was double-compressed, to save space, and sacked—triple-compressed hay being found to break up and become powdery. The cost of transportation, of course, varied, but with sled roads in good condition it was found that to take supplies to Millers Roadhouse, about 250 miles, cost about 13½ cents per pound. The cost increased greatly with the distance, as the supplies necessary for the sledding crews naturally reduced the amount of freight hauled.

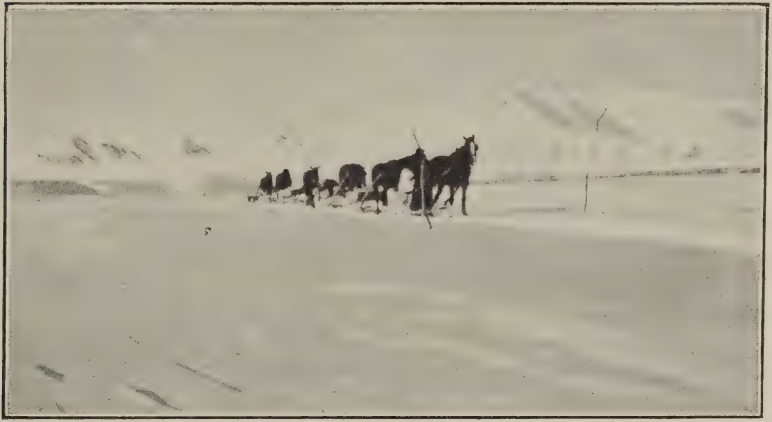


Fig. 7. Mail stage at summit Alaskan Range on the Valdez-Fairbanks Road, March 22, 1910.

In the spring any extra horses needed were bought, usually, in Seattle by the engineer officer or superintendent, and the road crews were organized. When there were not sufficient laborers in Valdez it was necessary to get them in Seattle, but this was seldom done, as the Alaskan laborer, being familiar with conditions, was much more efficient.

Thompson Pass was not usually open for summer transportation before about the middle of June. The crews would then be sent in to the different places where they were to work. The bridge crews left inside having completed their work would be started on road work, it being possible to start on this work before the crews could get over the pass. During the break-up, that is, when snow was melting, the pass is practically impassable. The crews usually returned early in October.

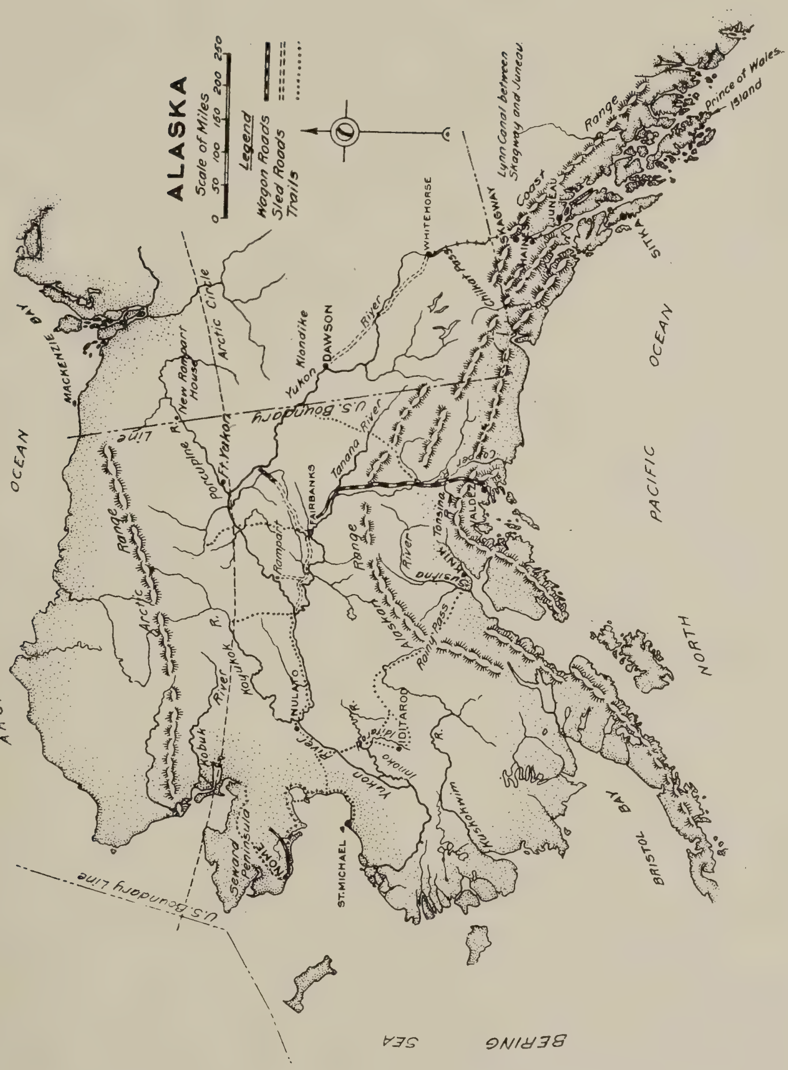
The total cost of the main line to July 31, 1912, including location and surveys, sled road and trail work, construction and maintenance, was $765,173.14, or $2,016.27 per mile.

The amount of freight going over this route, particularly in winter, is considerable, but hard to estimate. The same may be said of the number of passengers. The cost of transportation has been greatly reduced the year round. The winter mail service to Fairbanks, in 1910, was 800 pounds semi-weekly October 1 to November 23, and March 9 to June 1, and 1,600 pounds tri-weekly November 24 to March 8. The summer mail was 750 pounds semi-monthly to Gulkana. The time to Fairbanks was from seven to ten days, with an average of eight days. Since the completion of the Copper River Railroad and the Willow Creek-Chitina Sled Road, mail has been sent in by that route, thus avoiding the Coast Range and, I understand, saving con- the completion of the Copper River Railroad and the Willow siderable time. However, heavy snow slides often interfere with the railroad and the wagon road must be used. Four-horse bob-sleds are used for mail, passengers, and express, except over the two summits, where single-horse sleds are used. Mail from Fairbanks to Fort Gibbon is weekly by four-horse bob-sleds, about three days. From Fort Gibbon to Nome the mail goes by dog-sled. The average time, Valdez to Nome, about 1,100 miles, is about thirty days. It has been done with one dog team in twenty-three days, a little over 49 miles per day. The mail in most other places is taken by dog-sled.

Up to October 1, 1910, when I left Alaska, the following mileage had been constructed:

Wagon road	miles	759.44
Winter sled road	do	507.25
Trail	do	576.56
Trail staked permanent (iron stakes)	do	85.00

The previous winter 492 miles had been temporarily staked. This amount varies from year to year and, of course, has to be done over again each winter. The total expenditure to that time was $1,604,921.58. In addition, an expenditure of about


ALASKA
Scale of Miles
0 50 100 150 200 250
Legend
Wagon Roads
Sled Roads
Trails
ARCTIC
OCEAN
MACKENZIE BAY
New Rampart House
Arctic Circle
Klondike
DAWSON
Yukon
River
WHITEHORSE
Chilkoot Pass
SKAGWAY
HAINES
JUNEAU
Coast
Range
Lynn Canal between Skagway and Juneau
Prince of Wales Island
SITKA
OCEAN
PACIFIC
NORTH
U.S. Boundary Line
Porcupine R.
Ft. Yukon
Tanana River
Copper
FAIRBANKS
Rampart
VALDEZ
Tonsina
KNIK
Susitna River
Alaska Range
Rainy Pass
IDITAROD
Innoko
Kuskokwim R.
Arctic Range
Koyukuk R.
Kobuk River
NULATO
Yukon River
Seward Peninsula
NOME
ST. MICHAEL
BRISTOL BAY
U.S. Boundary Line
BERING SEA

$125,000 has been incurred covering pay rolls and supplies not yet paid for. From $75,000 to $100,000 of local road tax and public subscription had been expended on these routes under the direction of the board, making a total of approximately $1,829,000 expended on the work shown above including maintenance, surveys, and all other expenditures. The report of 1912 shows up to July 31, 1912: Wagon road, 829 miles; winter sled road, 599 miles; trail, 1,552 miles, and the total expenditure is given at $2,215,000. The average costs are, including all overhead charges: wagon roads, $2,200 per mile; winter sled roads, $250 per mile; trail, $100 per mile.*

The effect on freight rates in general, on the ease of travel, and on the mail service is very great and difficult to estimate. In fact, there are many mines and mining districts which would not have been opened up at all but for this work. It is but another one of the many ways in which the Army has helped and still is helping in the development of the country, and in building up its commerce.

Some additional construction work has been done since this article was written.

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*The report for the fiscal year ending June 30, 1913, states that 33 miles of wagon road, 18 miles of winter sled road, and 614 miles of trail were completed during the preceding year. The average cost per mile, including maintenance and overhead charges was: Wagon road, $2,489.68; winter sled road, $278.80; and trail, $90.44.—Ed.

Field Methods for Printing from Metal*

BY

Mr. HERMANN E. OSANN
Late Chief Lithographer, Army Service Schools

The first attempts to reproduce the work of sketchers more rapidly than by blue printing consisted in transferring the sketch to stone and taking prints by a lithographic method. A road sketch of a single day's march might be 60 to 72 inches long, requiring either a very large stone or making the maps up in sheets. The weight of the equipment and the time required lead to the development of other methods but the old name, lithographic outfit, still clings to the equipment.

The first difficulty to be overcome with the use of metal plates was to obtain a graining method more rapid than the tedious process of rolling them with marbles and pumice powder. The second difficulty was to obtain processes both independent of and dependent upon light without having to carry too great a variety of equipment. These difficulties have been overcome and processes developed which are simple and reliable enough for the field and give results good enough for all needs.

If a commercial worker should read the description of these processes, he would find some apparently glaring defects such as the use of dragons blood which roughens the ink surface to a certain extent and prevents a solid color in the copy; or the etching with nitric acid instead of with nut galls and phosphoric acid, since the nitric acid produces a slight relief and causes a broader and more uncertain line. The adoption of methods inferior to those of the commercial plant is explained by the fact that the former methods are more readily adapted to the particular conditions which a long sojourn in the field involves.

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*Prepared at the request of Maj. N. G. Caples, C. of E., Secretary of the Board on Engineer Troops, for the use of that board in the preparation of a lithographers manual.—Ed.

PHOTO-LITHOGRAPHIC PROCESS.

This process is dependent upon the action of light and differs from the photo-engraving process employed in newspaper and magazine work, principally in that the plate is not etched type-high but printed from in a lithographic manner. The great drawbacks to the process are its dependence upon light and the necessity of a negative. In the Middle West, experience of the last few years is that, out of any ten days in August or September, only four will have sufficient clear sunlight.

The original sketch is combined and traced in waterproof ink on tracing linen, tracing paper, or even sketching case paper. From this tracing, a negative—not a reversal print—is made on sepia solar or other suitable brown print paper. The paper ordered for this class of work must be intended specially for the making of negatives, as the ordinary kind is too thick.

The printing of the negative is carried out in the usual manner. If when still slightly wet the paper is exposed to artificial heat, the contrast between the opaque part and the white lines will be sharper. Pin holes (transparent spots) in the opaque parts of the negative are gone over with drawing ink. Undeveloped white lines are improved by going over them with oxalic acid.

A No. 19 wire gauge zinc plate is used. The ink, from previous printing is taken out with turpentine; the grease is removed by going over the plate with lye, and the old image is rubbed down with a Scotch hone. A new plate must be cleaned of grease. Any grease, even so much as left by a touch of the bare hand is injurious. The clean plate is polished by scrubbing with fine polished willow charcoal which has been previously treated with lye and should be kept in water when not in use. The plate is gone over with an even stroke, always in the same direction, and without too much pressure. Pumice powder similarly applied with a tuft of cotton hastens the polishing, but care must be taken that no trace of pumice is left on the plate.

The polished plate is coated with a sensitizing solution, consisting of:

White of one egg (or 120 grains albumen).
15 grains Ammonium dichromate C. P.
7 ounces water.

The egg is beaten or the dry albumen is dissolved in the water. The dichromate is pulverized with a mortar and pestle and then dissolved. A few drops of 28 per cent ammonia are added until the solution becomes a clear yellow. The solution is sensitive only when dry. To coat the plate the following rules should be observed.

Rinse the plate and, while still wet, pour the sensitizing solution over it by gliding the glass of solution over one edge of the plate. Repeat the operation and make sure that no dust particles or air bubbles are left upon the plate to enlarge in drying and break the film. Place the plate in a whirler and whirl to insure an even distribution of the sensitive coating. Then dry by holding over a source of heat and continuing the whirling. A kerosine stove, with heating surface nearby the same as that of the plate is best, but, with the single-burner stove carried in the field, the whirler should be kept swinging to insure uniformly rapid drying. As the plate dries, a dark circle appears in the center and enlarges rapidly. Swing the plate so that, as far as possible, only the undarkened portions are exposed to heat. When the plate is uniformly dark, remove it from the heater and put it in a dark place to cool.

Printing depends upon the fact that an organic substance, dried in the presence of an alkaline dichromate and exposed to light, becomes insoluble. As in all other dichromate printing, the contact must be very close and the rays of light must strike the negative approximately normal to its surface in order to prevent blurring on the lines.

The time of printing varies with the quality of the negative, the thickness of the sensitive film (which must be made insoluble clear through on the lines of the drawing) and the actinic intensity of the light. As a guide to exposure, a plate coated in the manner indicated and exposed under a perfect negative between 10 a. m. and 3 p. m. in July or August, and at about 37° north latitude, will require about 1.5 minutes in clear sunlight.

The brown side of the negative is placed is contact with the sensitive surface of the cooled zinc plate and printing is done in a process or other printing frame giving specially heavy pressure.

Etching ink is a preparation similar to ordinary litho ink, except resinous matter is more preponderant and coloring matter is sacrificed. It is extremely hard and must be worked with a mixing knife before being placed on the ink slab. In winter, it is specially resistant. It may be carefully thinned by adding a drop of aniseed oil.

After the plate has been exposed there should be no delay in working up. Before exposing the plate, a very small quantity of etching ink—about as much as will go on a five-cent piece—is spread on the ink slab and rolled out until both slab and roller are evenly coated with the ink. In garrison, a composition roller is used but the tendency of these rollers to deform when heated compels the use of a glazed leather roller in the field. This roller must never be scraped, but should be frequently washed with turpentine.

As soon as the plate is printed it is lightly rolled up with etching ink. Very little ink is required and the yellow tint of the coating should always be visible through the ink.

The plate now has insoluble lines upon a soluble ground, which is next dissolved. A simple immersion in water will not serve, as practically there is a light insoluble film over the entire surface. The plate is placed in water and rubbed lightly with a tuft of cotton. If the exposure is correct, the lines will remain and the ground will dissolve. In an underexposure the lines float away and are lost. An overexposure gives a solid ground, but may be helped by adding a few drops of ammonia to the water. Portions of the coating not covered by the negative will be entirely insoluble and are removed by pumice on a tuft of cotton. The plate should leave the water with black lines on a clear white ground.

The plate is taken from the water and dried by patting with a damp chamois skin. Rubbing will destroy the lines. Messing lines are painted in with a red sable brush and a little etching ink moistened with turpentine. Unless the lithographer be an expert with the brush, this work should be done by a draftsman.

The plate now shows a true image of the drawing. Before describing the preparation for printing, a few words should be said as to the principles governing the method. Printing from type and type-high plates is very simple, but printing from an even surface depends upon the principle that water and grease are mutually repellant. Water leaves a greasy surface and adheres to one free from grease, while grease adheres to a greasy surface and is repelled from a wet one. The grease, in the present case, is represented by the ink covered lines of the image and the surface by the whites of the plate. The ink on the printing roller represents the grease brought to this surface, adhering to the lines and being repelled from the whites. To obtain the greatest contrast, the pores of the plate are opened with acid to destroy any tendency of the whites to take ink and to make them fit to receive a quantity of gum which will sink into the pores and, once dry, prevent the water, which is frequently passed over the plate in printing, from sinking into the pores and leaving the whites prematurely dry. The ink lines are theoretically capable of repulsing the attack of the acid, but practically they must be reinforced by a resinous powder. The resinous powder most suitable for printing in open air and a daily move of of the outfit overland is known as dragons blood.

The completely dried plate is exposed to the sun or to artificial heat until the ink lines just lose their gloss. It is cooled and then dusted with dragons blood on a tuft of cotton, brushing the powder all over the plate. The plate is then dusted with a camel's hair brush and a tuft of fresh cotton until only the lines show dull red. Where running water can be had under pressure this dusting is done by placing the plate under a shower spray. Dragons blood must not be applied when the plate is hot.

The plate, with the dragons blood adhering only to the lines, is heated until the lines change to a deep brilliant black, caused by the fusing of the resin and its combination with the ink. The plate, which has warped in the heating, is then allowed to cool on a flat surface until it again becomes flat. All imperfections are removed with an engraving needle, leaving the plate ready to etch.

Etching means rather the opening of the pores, not intaglio etching nor relief etching. Commercially, the etching is done with phosphoric acid and chromic acid or nut galls to avoid a change in the level of the surface, but, in the field, nitric acid is substituted. This acid does give a slight relief to the lines, but its action on the whites is complete before the level of the surface has been materially changed. The etch used consists of:

Nitric acid, commercial, 38°	4 ounces.
Water	2 gallons.

The etching bath is made in a wooden tub, water and acid proofed with asphaltum paint and large enough to allow the plate a comfortable margin to prevent the bath becoming stagnant over the plate at any time while the tub is being rocked during the etching process. The plate is preferably gone over along the edges with pumice to remove finger marks before etching. A wiping with acetic acid improves the cleanliness of the plate, which is then washed free of pumice and acetic acid and placed in the etching bath.

The tub is set rocking just previous to immersing the plate. As soon as the plate is put into the bath it shows a gray scum, which is removed with a bristle brush. The plate is kept in the bath from a minute to a minute and a half, scum being removed as fast as it forms, and is then taken out and immediately washed free of acid.

The plate being free of dirt and scum, the next step is to gum it up with dextrine by gliding the glass containing the dextrine solution over one edge of the moist plate and then repeating the operation. Dextrine has proven the best gum for handling plates in the field The solution is made, viz:

Starch.

Dextrine	1 pound.
Water	1 pint.

Use equal parts of water and starch for gumming plates. The solution is made by boiling. The gum should not be too thick, else it will crack on the plate, nor too thin, else it will fail to fill the pores.

After a plate has been gummed it should be allowed to drain and, if not immediately required, to dry for about an hour. The plate is now ready to print.

AUTOGRAPHIC TRANSFER PROCESS.

This process is independent of light and is used when the light does not admit of the finer photo-lithographic process. It is peculiarly adapted to use in connection with the latter process, since a number of the operations are identical, thereby reducing the amount of equipment necessary. The process was developed as the result of an experimental reconnaissance march and has since proven its suitability under field conditions.

The sketches are combined and traced with a mixture of autographic ink and touche, either on the original paper on which they were made or on India transparent transfer paper. The latter gives finer work, but the touch of a sweaty hand upon its surface will take on the plate. Liquid touche is better to use than the stick form, which requires a skill of manipulation that can be obtained only by long practice. The proportions of the mixture may be left to the draftsman, provided that at least half is autographic ink. Care must be taken to ink the lines evenly and not to exert much pressure, as pressure will break the delicate coating of the transfer paper. If a heavier line is wanted, it must be obtained by using more ink.

The tracing, or transfer, dries in from five to ten minutes. It is then placed in a damp book, consisting of sheets of blotting paper.

A moderately wet sponge is passed over the outsides of the two blotters so that the transfer will become slightly damp, but not moist or wet. The transfer is left in the damp book about five minutes, until it becomes damp and shows a wavy appearance.

The surface of the zinc plate must show a certain roughness or grain. The field graining of a plate, instead of being done by working for hours with marbles and pumice or rolling in a special press, is finished in a few minutes by the following method which is the chief feature of the process. The etching tub is filled with the following bath:

Water	1 gallon.
Nitric acid (commercial, 38 per cent)	2 ounces.
Alum	1 ounce.

The polished plate is cooled in water and then immersed in the bath, which is gently rocked. The plate is left in the bath about a minute, removed, rinsed, and patted with a tuft of moist cotton to remove the scum. It now shows a silver gray appearance and a distinctive grain. The plate is dried with a deep chamois skin and then exposed to the sun or to artificial heat until it is slightly warmer than the tent or room. The plate is placed on a flat object.

The transfer is taken from the damp book, placed face down upon the plate, and run once through the press with very slight pressure to remove wrinkles and not heavy enough for the autographic ink to leave any trace on the plate. The plate and transfer are run through the press several times more with increasing pressure at each run until the maximum is reached at the fifth run. The plate is now turned 180° in the press and the process repeated. After the fifth run in this position, the transfer is moistened with a sponge and peeled off.

The autographic ink leaves the transfer and adheres to the zinc. The plate is washed thoroughly to remove the gum particles left by the India paper which, if allowed to remain, will absorb some of the etching powder and cause trouble. Do not be afraid to press hard on the sponge; the lines of the image will not blurr. The plate dried first with a dry chamois skin and then by fanning or by exposing to the sun or to artificial heat. The plate is next worked up with dragons blood and treated exactly as in the photolithographing process, the succeeding operations being identical in the two processes.

Perhaps in the autographic process the commercial etch of nut-galls and phosphoric acid is more desirable than in the photo-lithographic process, but simplicity of field equipment requires the nitric acid etch to be used. The following rules should be observed. Watch the lines of the image closely, remembering that, while they offer a certain resistance to the etch, if this resistance is exceeded the lines will be under-cut and lost.

On the other hand, a thorough etching is necessary, any grease particles left being liable to print, and any unopened pores of the zinc refusing to take the gum.

REVERSAL PROCESS.

The necessity of making a maduro negative for the photo-litho process led to experiments to find some way of reversing the printing on the plate, so that the negative might be dispensed with. These experiments have led to the development of a process which, while not giving such critical results as the photo-lithographic process, is entirely practical.

Either a tracing is used or the copy is made translucent by banana oil, a preparation that acts like castor oil but is not offensive in odor and does not affect the other materials used in the work. A plate is sensitized exactly as for the photo-lithographic process and printed and rolled up with etching ink in exactly the same manner.

After development in water, the plate shows white lines on a black ground. The succeeding steps are to change this condition to black lines on a white ground.

The plate is powdered with dragons blood and etched, but the etching is continued until a slight depth is given to the lines. Common asphaltum paint is now rubbed into the lines until they are entirely filled. The plate is now polished with charcoal which removes the etching ink and albumen, leaving only the asphaltum paint in the ground lines. The reversal is now complete, the plate showing black lines on a white ground. Another dip into the etching bath brings the lines, protected by the asphaltum paint, to the same level as the rest of the plate and removes all grease from the whites. The plate is now ready for printing.

PRINTING.

The printing is the same in all three processes and depends upon the mutual repulsion of water and grease, no account being taken of any slight relief which the lines may have. The rules for printing are the following:

Use two rags, one for the removal of the surplus dry gum at the beginning of printing and the other for the dampening of the plates before each impression. The dampening water should contain a little dextrine, the amount depending upon the season, temperature, humidity, character of paper, etc. Too much dextrine causes the paper to stick to the plate and smears the roller, while too little causes premature drying and makes the ink smear on the plate. Use the least possible amount of resistance on the rag, as the less one has without exposing the plate to smearing the better will be the results. Each copy requires a dampening and rolling up of the plate. If the lines become surcharged with ink, take one copy without rolling up.

Scrape the roller each day, devoting special care to the edges, and clean it once a week with turpentine and a fine wire brush. Then let it rest a day before using again. At the conclusion of the day's work, leave black ink on the rollers until commencing work next day. This rule does not apply to colored inks. Scrape a roller only in the direction of the grain. Once a month, after scraping and then cleaning with turpentine, roll the roller thoroughly in litho varnish and let the varnish soak over night. Scrape the varnish off next day. If a roller has not been used for some time, clean and cover with vaseline, lard, or any grease not absorbed by the skin. Scrape and wash with turpentine before using.

Work the litho ink thoroughly up with muller and spatula and leave no solid particles in the ink; distribute the ink on the ink slab by means of the spatula, going from the right to the left with an even stroke; start with little ink and increase the amount gradually; never put ink directly on the roller. Do not use varnish in the ink, but be careful to have the roller saturated with varnish.

Avoid flat and glossy paper for printing purposes; if you have to use it, fan the plate dry after each rolling up.

If you use stiff ink on the roller, go over the plate with a slow motion using moderate pressure; by using a swift motion you are liable to take more ink from the lines than you will add to it. If, on the other hand, you use a soft and liquid ink, go over the plate with a swift movement, as otherwise you will broaden the lines and run the danger of smearing up the plate. Once over the plate, give your wrist a quick jerk so that during the backward movement of the roller a new part of its surface will come in contact with the plate. The ink should in warm weather be stiffer than in cold.

If through carelessness some of the whites have been omitted during dampening, they will take ink during the successive rolling up. Dampen the plate again and give it a quick roll; the ink will disappear from the whites.

If through continuous carelessness during the dampening process or through the use of too liquid ink the plate should become smutty and the lines of the impression should appear blurred, gum the plate with dextrine using a rather thick solution and, while the dextrine is still liquid, wash the ink off the plate with turpentine, being careful that no pressure is exerted upon the lines. The ink being removed, keep the plate for several minutes under running water in order to remove the turpentine. Then gum up with the ordinary solution of dextrine and let the gum dry. The plate prepared in this way can be kept for years.

POSSIBLE DEVELOPMENTS.

The lithographic equipment as now used is quite heavy and bulky. At the Army Field Engineer School, the tendency of experimental work is to reduce and simplify the equipment. In the photo-lithographic process, the negative has been fastened to the plate with clamps and plate bent to secure contact. The results give hope that the heavy printing frame may be dispensed with. Printing has been accomplished, with fair results, by laying the plate upon a level surface and running over the paper with a common print roller. If experiments along this line succeed it may be possible to dispense with the press.

THE HECTOGRAPH.

The hectograph is referred to in the Field Engineering Manual as a ''make-shift,'' which is correct when we consider only the old time hectograph consisting of a mixture of gelatine and glycerine. But one of the foremost manufacturers of drafting implements puts an hectograph on the market where the wabbly gelatine is replaced by a solid matter and where the lines of the image appear as sharp and distinct as the average lithographer of the engineer battalions will be able to procure them on his zinc plate. The other objection made in the manual, the fact that the prints will soon fade, does not refer to the prints made from this improved hectograph; samples of these prints were kept in water for two days and afterwards exposed to Texas sun without deteriorating materially their appearance.

The chief advantages of this improved hectograph are the following: its cheapness—an outlay of about $6 should be sufficient to keep an outfit, capable of printing copy of the 24 by 36 inch size, going for months; its simplicity—any draftsman can handle the special ink and any one obtain copies from it; its speed—once the drawing made, 60 to 75 copies can be obtained in about fifteen minutes; its portability—a medium size outfit, including ink and printing paper, can easily be carried in a saddle-bag; and the fact that prints seven different colors can be obtained without special preparations.

To illustrate the importance which the last named quality of the hectograph may have: suppose a division commander is directing his line of battle by means of graphic tactics and he finds it desirable to inform his sub-commanders of the position on a given moment. The field lithographic outfit of the division has furnished the previous night a number of lithographed copies of the terrain. Anyone in the suite of the division commander acquainted with the rudiments of drawing can mark down on a copy of the lithographed map the positions of the various units, indicated by flags on the map of the division commander. If he uses blue for infantry, yellow for cavalry, red for artillery, etc., he will obtain an image of the position which can be taken in at a glance. If each chief of an infantry battalion, troop of cavalry, battery, section of engineers and signal corps has to be informed about sixty copies will be necessary, a number which the hectograph is able to handle. If the required number of mounted orderlies is at hand and the line of battle not more than 14 miles wide, each sub-commander in the division should be informed of the position of his co-combatant in less than an hour's time.

If the lesser units are supplied with the improved hectograph and the lithographic outfit restricted to a division, the outfit could of course be more elaborate and consequently able to produce better work; and this may become imperative if half tones are required to be printed.

POSSIBLE NEW REQUIREMENTS.

Various improvements in the military art seem to indicate that half-tones—that is, pictures from nature with the graduations of light and shade, will be necessary during field operations; first, the fact that aeroplanes are able to take bird's-eye views with the camera and, second, that the transmission of photographic plates by wire seems to have arrived at a practical point; at least the Italian army, the last to have been in active service, has per decree of June 27, 1912, established a photographic section in connection with its signal service with the object of reproducing telephotograms.

NOTE: The distribution of equipment recommended by Sergeant Osann has been made. Each company tool wagon carries a small hectograph equipment. Each headquarters of engineers with a division had a lithographic outfit, using the Holabird press. A different set of methods was used at Washington Barracks from those above described. At present, the equipment and supplies are made sufficient to cover both sets of methods. After a sufficient comparison has been had of the two sets of methods, one or the other will be adopted as standard and the amount of equipment and supplies carried will be reduced accordingly.—W. G. C.

Some Damage by the Lake Storm, November, 1913

BY

Lieut. Col. MASON M. PATRICK
Corps of Engineers; Member American Society of Civil Engineers

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On November 9-10, 1913, there swept over the Great Lakes a storm more severe and more disastrous than any which has ever been experienced during a navigation season. The loss of life was great and the damage done enormous.

On the morning of November 9 the wind was blowing freshly from the northwest on Lake Huron. By the afternoon of that day it had shifted to the north, and had increased greatly in violence. Without abating, it continued all of the night of November 9-10, and then died away toward noon on the 10th. For at least sixteen consecutive hours the average velocity of the wind was not less than 60 miles per hour.

This long-continued storm from the northwest and north caused tremendous seas, especially in the lower part of Lake Huron. According to the Weather Bureau charts, on the morning of November 8, the storm center had moved eastward from Minnesota to the eastern end of Lake Superior with a barometric reading of 29.42 inches at Sault Ste. Marie. The chart for November 9 shows a remarkable area of low pressure central over Washington, D. C., barometric reading 29.1 inches. The next morning its center was near the western end of Lake Ontario, barometer at Buffalo, N. Y., 28.96 inches. By the next morning it had disappeared to the northeastward. At Detroit, during the storm, the lowest reading was 29.11 inches. All barometer readings are reduced to sea level.

The following table gives some details of the damage to shipping:

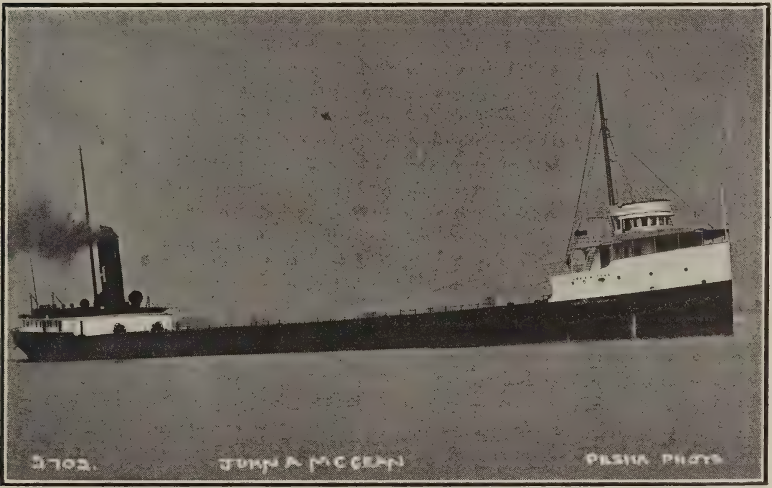
Name.	Material.	When built.	Length over all. Feet.	Beam. Feet.	Depth. Feet.	Carrying capacity. Tons.	Where lost.
Total Losses.							
Str. Chas. S. Price	Steel.	1910	524	54	30	9,000	Lake Huron.
Str. Isaac M. Scott	Steel.	1909	524	54	30	9,000	Lake Huron.
Str. H. B. Smith	Steel.	1906	545	55	31	10,000	Lake Superior.
Str. James Carruthers	Steel.	1913	550	58	31	9,500	Lake Huron.
Str. Wexford	Steel.	1883	270	40′1″	16′7″	2,800	Foot of Lake Huron.
Str. Regina	Steel.	1907	269	42′6″	23	3,000	Lake Huron.
Str. Leafield	Steel.	1892	269	35′3″	16′6″	3,500	Argus Island, Lake Superior.
Str. John A. McGean	Steel.	1908	452	52	28	7,500	Lake Huron.
Str. Argus	Steel.	1903	436	50	28	7,000	Lake Huron.
Str. Hydrus	Steel.	1903	436	50	28	7,000	Lake Huron.
Bge. Plymouth	Wood.	1854	225	35	13	600	Gull Island, Lake Michigan.
Lightship No. 82	Steel.	1912	105	21	14	180	Point Albino, Lake Erie.
Bge. Halsted	Wood.	1873	191	32	12′6″	800	Green Bay, Lake Michigan.
Constructive Total Losses.							
Str. L. C. Waldo	Steel.	1896	472	48′2″	28	7,000	Manitou Island, Lake Superior.
Str. H. M. Hanna, Jr.	Steel.	1908	500	54	30	8,500	Pointe Aux Barques, Lake Huron.
Str. Major	Wood.	1889	303	41	22	3,000	Near Whitefish Pt., Lake Superior.
Str. Matoa	Steel.	1890	310	40	25	3,104	Pointe Aux Barques, Lake Huron.
Str. Louisiana	Wood.	1887	287	39	21	2,800	Washington Island, Lake Michigan.
Str. Turret Chief	Steel.	1896	273	44	19′7″	3,100	Copper Harbor, Lake Superior.

All of the vessels listed in the "Total Loss" Table foundered with all on board. As nearly as can be determined, the loss of life totaled 235, on Lake Superior 44, Lake Michigan 7, Lake Erie 6, Lake Huron 178.

The vessels listed in the "Constructive Total Loss" Table were driven ashore and so damaged that they could not be floated.

In addition, there were a number of other vessels driven ashore, but subsequently released. The money value of the vessels totally lost amounted to $3,162,900; the damage to vessels stranded but later released is estimated at $620,000, and the losses on cargoes at $1,000,000, making the aggregate of losses $4,782,900.

The tables above show that among the vessels lost were some of the newest and best lake boats. Exactly what happened to those that foundered will never be known, as they carried down with them every member of their crews. The steamer *Chas. S. Price*, 524 feet long, is known to have turned turtle. This wreck was discovered about 11 miles from the lower end of Lake Huron, in water about 60 feet deep, bottomside up, its after end resting on the bottom, its stem showing above water about 18 feet. As the air in its forward compartments escaped, the wreck gradually settled to the bottom of the lake where it lies with about 30 feet of water over it.



The steamship John A. McGean is the type of boat, many of which were lost in this storm. She was 452 feet long, 52 feet beam, and was built in 1908, and foundered during the storm with all on board.

The officers of the *H. M. Hanna, Jr.*, 500 feet long, which was blown ashore at Pointe Aux Barques, Lake Huron, have made a valuable record of their experiences. This vessel, loaded with 9,000 tons of coal, drawing about 19 feet forward and aft, was north bound. Between 7 and 8 p. m., on November 9th, she was some 15 miles north of Point Aux Barques and had begun to drop off her course, though the engines were being worked full speed ahead, and she was taking heavy seas over her bow and starboard quarter. Shortly after 8 p. m., she fell off into the trough of the sea and became unmanageable so that it was impossible to head her again into the sea or to turn her and run before it. She struck about 10 p. m., pounded on the rocks and later broke in two.

These large lake bulk freighters are well built, but in their design the controlling considerations are maximum cargo space, ease and rapidity of loading and unloading. The boilers, machinery and crew's quarters are located near the after end, between which and the pilot house and officers' quarters far forward the hull is divided into cargo compartments covered with many hatches.

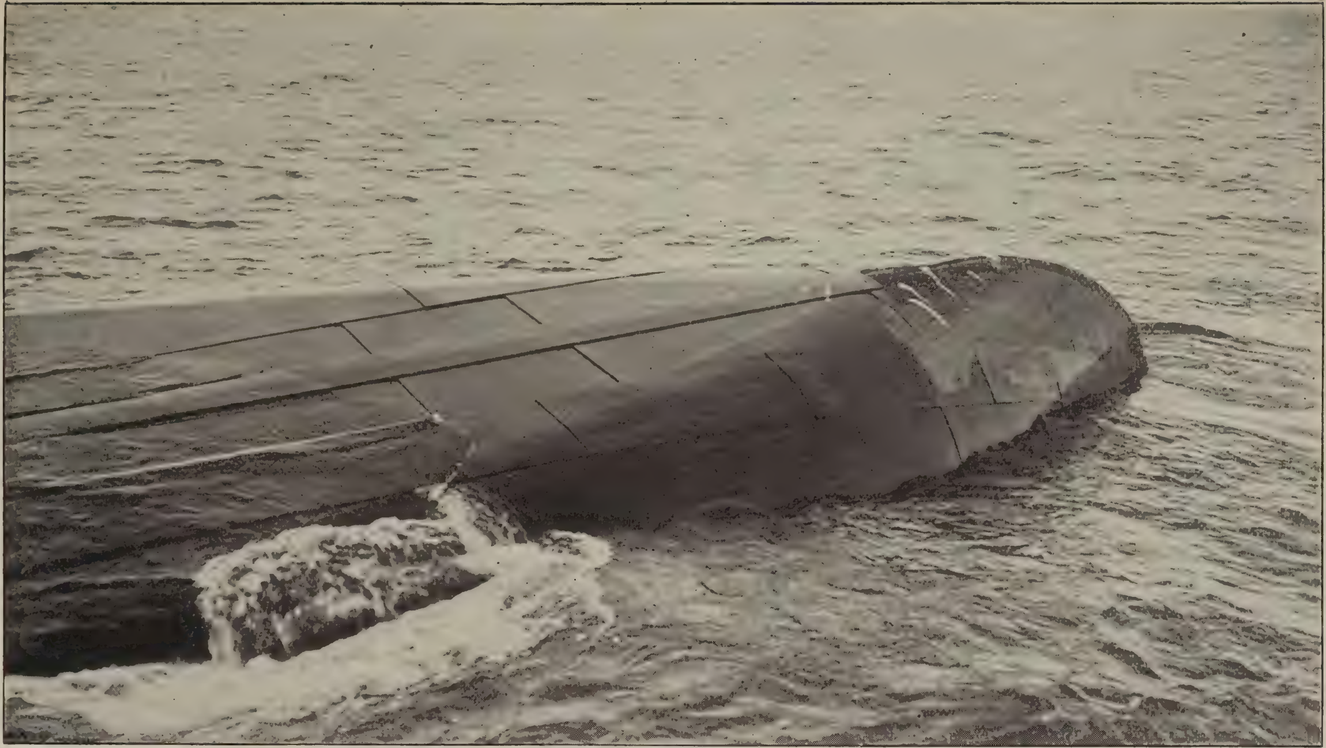
The propelling engines of the largest boats develop only about 2,200 horse-power and drive them through the water at an average speed of about eleven statute miles per hour. It seems evident from the statements of her officers that the *Hanna's* power was not sufficient to drive her into the sea nor to enable her to work her way out of the trough and turn to run before it.

If the stories of the vessels that foundered could be known it is probable that they would differ but little from that of the *Hanna.* Unable to battle their way against wind and sea, they fell off into the trough, or the seas coming over aft may have flooded their engine rooms, or their rolling may have caused their cargoes to shift or the terrific pounding may have opened their cargo hatches or started their seams.

The depth in the inter-lake channels limit the draft of these lake freighters and it is manifest that no radical change in their design with a view to making them more seaworthy can be made without diminishing their cargo carrying capacity.

It is doubted whether any such change will be made. This storm was so unprecedented and of such exceptional duration and violence that the chance of its repetition is remote, and shipping will probably take this chance rather than incur the enormous expense of preparing to meet a contingency which may not arise again for many years.

As the major portion of the disasters occurred on Lake Huron



A very graphic photograph of the Steamer *Charles S. Price* ''turned turtle.'' She was built in 1910 and was 524 feet long. She was lost in Lake Huron. (Copied, by permission, from the *Marine Review.*)

and many of them near its lower end, it was suggested that further improvement of the channel between the lake and its outlet, the St. Clair River, might lessen the danger to shipping. This matter has been considered with care, but a study of all the known facts fails to warrant the conclusion that any inadequacy of the existing channels was responsible for any of these disasters, or that any enlargement of it is necessary.

DAMAGE TO GOVERNMENT WORKS.

The damage done to protective harbor works on Lakes Superior and Michigan was not notable. On Lake Huron much damage was done to the breakwaters surrounding the harbor of refuge at Harbor Beach. This harbor is shown in plan in Fig. 1. It will be remembered that the storm at its height was from the north and that its direction shifted but little during its continuance.

The construction of this harbor was commenced in 1873 under a project which provided for three separate piers or breakwaters, of crib-work filled with stone, located so as to shelter an area of about 650 acres. This work was finished in 1885 at a cost of $971, 000, including maintenance to that date.

The upper portions of these crib structures having decayed as usual, and having been damaged by storms, plans were prepared for cutting them down to a little below water level and then building in their places concrete block superstructures. By the end of 1911 the superstructures of the north pier, of the main pier, and a concrete pier-head on the south pier had been completed, and since that date the work has been suspended waiting a further appropriation. An excellent description of this work will be found in the article by Mr. E. J. Duffies, Assistant Engineer, Member American Society Civil Engineers, published in PROFESSIONAL MEMOIRS, September-October, 1912, from which the cross-sections shown in Fig. 2 are taken.

The section with the parapet in the middle was used for nearly all of the main breakwater, the one with the parapet on the lake side being placed on its short portion below the angle just above the light-house. (See Fig. 1.)

The north pier suffered little damage. The main breakwater runs about northwest, southeast, and during the height of the storm the wind and sea struck it at an angle of about 40 degrees. Nine vessels which had sought shelter in the harbor were tied up along the inner side of this pier. So great a volume of water came over

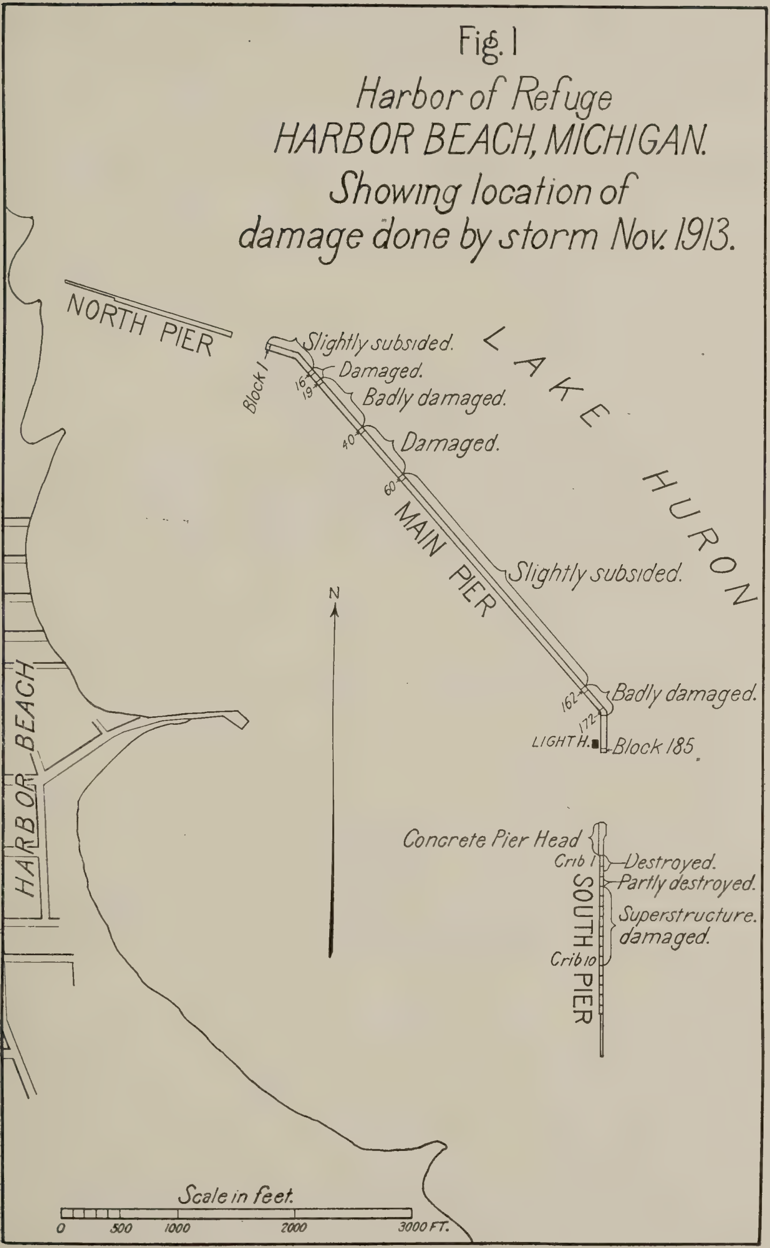


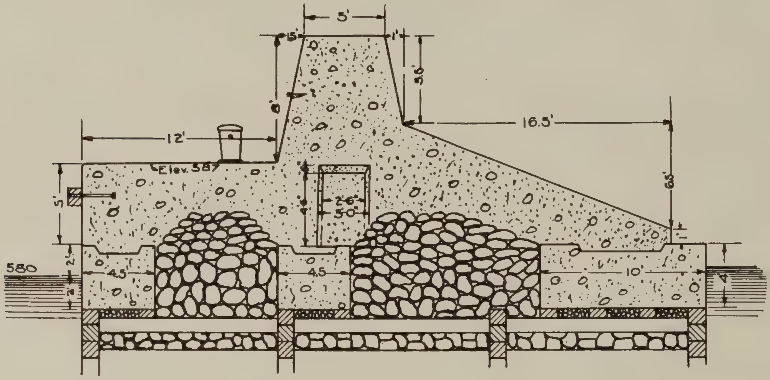
Fig. 1

Harbor of Refuge
HARBOR BEACH, MICHIGAN.
Showing location of
damage done by storm Nov. 1913.

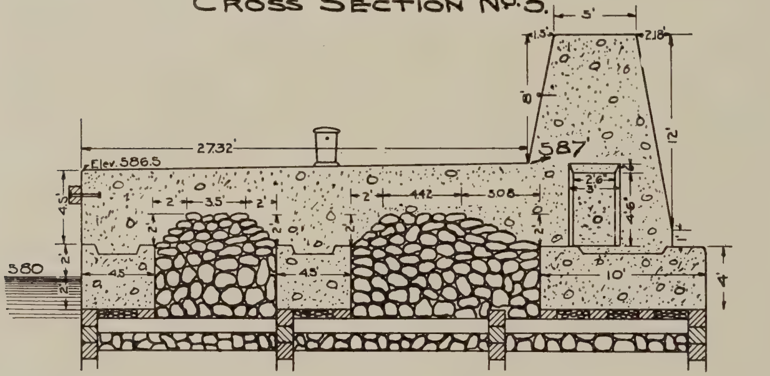
NORTH PIER
LAKE HURON
Block 1
16
19
40
60
162
172
Slightly subsided.
Damaged.
Badly damaged.
Damaged.
MAIN PIER
Slightly subsided.
N
Badly damaged.
LIGHT H.
Block 185
HARBOR BEACH
Concrete Pier Head
Crib 1
Destroyed.
Partly destroyed.
Superstructure. damaged.
Crib 10
SOUTH PIER
Scale in feet.
0
500
1000
2000
3000 FT.

it that they were forced to leave their moorings and anchor in the harbor where three of them later dragged their anchors and went aground. The storm raised the level of the water in the harbor to about 4 feet above normal and when it receded these vessels were hard and fast on the bottom.

This main breakwater is 4,695 feet long and the superstructure


5'
1.5'
1'
3.5'
8'
12'
16.5'
Elev. 587
2.6'
5.0'
6.5'
5'
2'
2'
580
4.5'
4.5
10'
4'

CROSS SECTION No.3.


5'
1.5'
2.18'
8'
12'
27.32'
587
Elev. 586.5
4.5'
2'
3.5'
2'
2'
4.42
5.08
2.6'
3'
2'
2'
580
4.5'
4.5'
10'
4'

CROSS SECTION No.4.

Fig. 2. Cross section of Concrete Superstructure of the Main Breakwater, Harbor Beach, Mich., as actually constructed.

consists of 185 blocks numbered consecutively from the upper to the lower end. The cribs had been leveled off as well as possible and then, as shown in the cross-sections, Fig. 2, there were placed footing blocks which were 10 feet long, 4.5 feet wide and 4 feet high. The outer row was laid as headers, the two interior rows as stretchers and under the joints of the adjacent monolithic blocks were placed cross blocks 4 ft. wide, 4 ft. high and from 7.5 to 11.5 ft.long.

All of the footing blocks had joggles or panels moulded in their adjacent vertical faces and in their upper faces for binding them to each other and to the mass concrete. This mass concrete in each block amounted to about 200 cubic yards, and is estimated to weigh about 340 short tons.

Blocks 1 to 15, inclusive, suffered little damage. Blocks 16 to 60, inclusive, were all more or less damaged. Most of these blocks are broken at the base of the parapet on its inner side and have settled to the front, the cracks varying in width from about two inches to over a foot. In a number of cases, the concrete of the slope from the parapet to the outer edge of the block has been broken in several places. (See Fig. 3.) On nearly all these blocks there has been much spalling and attention is invited to the photograph of block No. 38. The upper portion of its parapet has entirely disappeared. Blocks 61 to 161, inclusive, show some subsidence and some spalling, but the damage to this portion was not great. Blocks 162 to 172 inclusive, are in about the same condition as blocks 16 to 60, the crack at the inner base of the parapet varying in width from an inch to over twenty inches. Along all the portions of the breakwater where the damage is greatest, in many cases the footing blocks on the outer side have disappeared, the rubble filling between the outer row of blocks and the first inner row has been washed out and the mass concrete above has settled to the front.

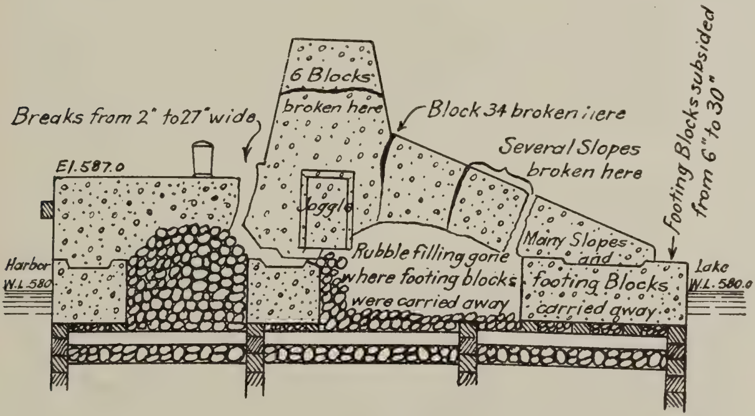
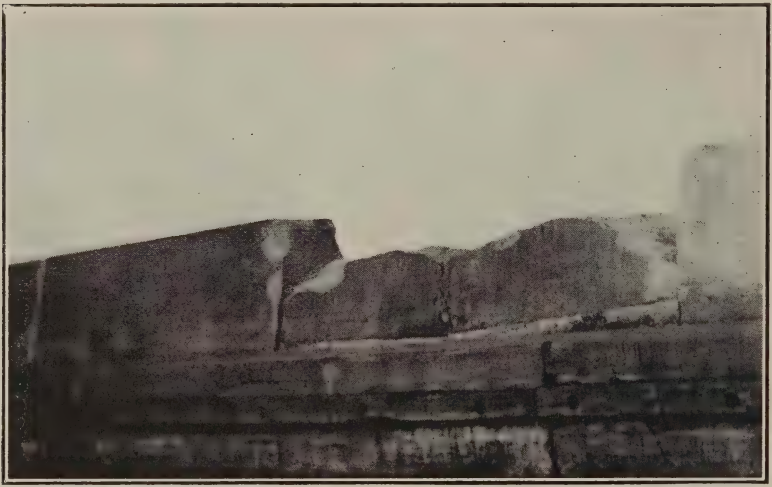

6 Blocks
broken here
Breaks from 2" to 27" wide
Block 34 broken here
Several Slopes broken here
Footing Blocks subsided from 6" to 30"
El. 587.0
Joggle
Harbor W.L. 580
Rubble filling gone where footing blocks were carried away
Many Slopes and footing Blocks carried away
Lake W.L. 580.0

Fig. 3. Typical Section of Main Breakwater showing Damage done by Storm Nov. 1913.

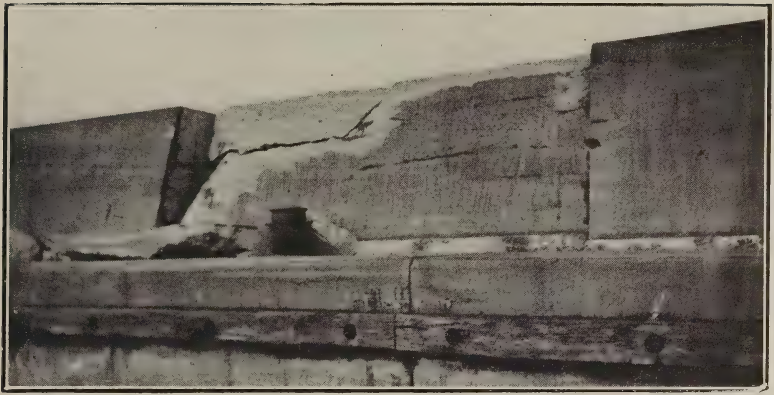
When the cribs were being prepared for the superstructure, the surplus stone removed from them was placed as riprap along the outer face of the breakwater. This was in general one-man stone and is said to have taken a slope of about 1 on 2, the depth before it was put in place having been about 15 to 20 feet, and the depth next the cribs after it was placed, about 6 feet. The seas have washed this riprap down, flattened its slope, so that now the average depth along the front of the breakwater over the riprap is about 14 feet.

South Pier. The concrete superstructure of the pier-head suffered little damage. Attention is called to the fact that this superstructure was built without footing blocks. The cribs south of the pier-head down to crib 10 were badly damaged, the first two south of this pier-head so badly that if the concrete superstructure is to be extended on this pier, they must be entirely renewed. From the other eight cribs in this section the decking is gone, many of the stringers have disappeared and much of the stone ballast is gone. South of this section, the remaining cribs were damaged but little, though all of them show a list shoreward.



Block No. 38, Main Pier, Harbor Beach, showing damage by storm of November, 1913. View from harbor side.

An examination of the cross-section shown in the drawings makes it very apparent that the breaks in the blocks of this superstructure occurred just where they might have been expected and indicates



View from harbor side. Damage to concrete superstructure, Main Pier, Harbor of Refuge, Harbor Beach, Mich., by November storm, 1913.

View from lake side, showing damage to Main Pier, Harbor of Refuge, Harbor Beach, Mich., by November storm, 1913.

the advisability of abandoning the footing block method. The weakness of this section was pointed out by Mr. Duffies in his paper, in which he states that recognition of this fact lead to the elimination of the footing blocks from the later plans for the superstructures of the north and south piers. In this connection, attention is invited to the discussion of Mr. Duffies paper by Mr. B. A. Todt, page 578, Professional Memoirs, Sept.-Oct., 1912.

The total cost of this harbor, including maintenance, to date has been $2,010,000, and in the thirty-five years from 1877 to 1912, it sheltered 40,000 vessels, the tonnage of which aggregated 19,200,000 short tons. Owing to the changes which have taken place in the types and sizes of lake vessels, during late years there has been a decrease in the annual tonnage seeking shelter here, but this harbor of refuge is still of importance and should be maintained. Where the greatest damage has been done to the superstructure of the main pier, it would be a costly operation to tear out the damaged blocks and replace them, while this alone would not make the breakwater safe against a storm of like violence. It is proposed to riprap heavily along the entire length of this main pier, using small stone for the core of the mass and covering it with stone blocks as large as can be obtained, making the slope about one on one and a half, carrying the riprap well up to the base of the existing superstructure and filling in as well as possible where the stone ballast has been washed from under the concrete blocks. (See Fig. 4.) The blocks which have been most damaged will be patched with concrete anchored with steel rods.

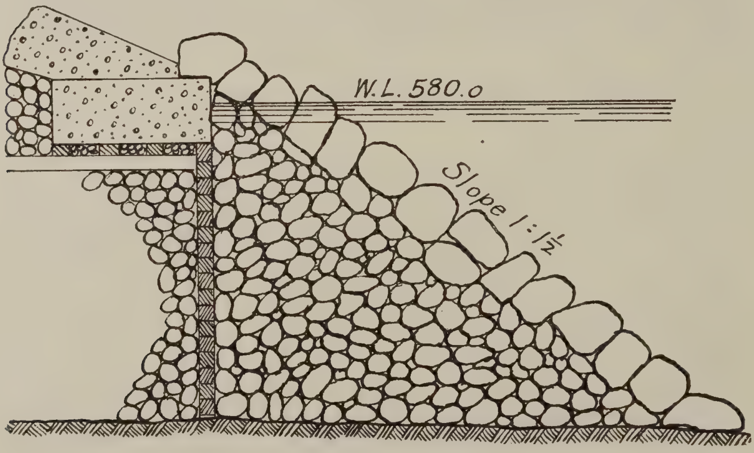


Fig. 4 Proposed Riprap.

Damage to Harbor Works in the Cleveland, Ohio, Engineer District Caused by the Storm of November, 1913

BY

Mr. R. B. PERRY
Junior Engineer

On November 8-11, 1913, the Great Lakes were swept by the most disastrous storm in their history. The resulting loss of life and property was unprecedented.

It is the purpose of this article to discuss more especially the damage to harbor works in the Cleveland, Ohio, Engineer District. While the storm was most violent on Lake Huron, as indicated by the large proportion of vessel losses occurring there, it was almost equally severe on Lake Erie. On page 346 is a record of wind velocities and directions covering the period under consideration, as furnished by the Cleveland office of the United States Weather Bureau, together with similar data for one of the more severe storms occurring during 1912, typical of ordinary storm conditions on the Lakes.

A comparison of these storms is afforded by the following figures:

	Nov. 1912.	Nov. 1913.
Maximum velocity (for 5-minute period)____miles per hour__	50	79
Wind 10 miles per hour or more:		
Duration ______hours__	35	65
Average velocity for period______miles per hour__	28.3	27.2
Wind 20 miles per hour or more:		
Duration ______hours__	28	27
Average velocity for period______miles per hour__	31	41
Wind 30 miles per hour or more:		
Duration ______hours__	17	22
Average velocity for period______miles per hour__	36.2	44.5
Wind 40 miles per hour or more:		
Duration ______hours__	6	15
Average velocity for period______miles per hour__	40.7	49.5
Wind 50 miles per hour or more:		
Duration ______hours__	0	7
Average velocity for period______miles per hour__	0	53.7

Date.		Hour of day.																							
		A. M.												P. M.											
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
1913.																									
Nov. 8	Direction	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	SW	SW
	Velocity	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	8	8
Nov. 9	Direction	W	SW	SW	NW	NW	NW	NW	NW	N	NW	NW	NW	NW	NW	W	NW	NW	NW	W	W	W	W	W	W
	Velocity	11	9	10	15	15	16	24	23	25	29	31	31	31	38	51	55	57	50	55	55	53	48	46	50
Nov. 10	Direction	W	W	W	W	W	W	W	W	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW
	Velocity	50	48	44	41	40	36	35	33	27	18	21	21	21	21	20	18	17	21	20	20	20	20	21	18
Nov. 11	Direction	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	S	S	S	S
	Velocity	17	16	18	16	17	17	17	22	22	21	19	18	15	14	17	14	14	13	12	12	13	13	12	14
1912																									
Nov. 8	Direction	----	----	----	----	----	----	----	----	----	S	S	S	S	S	SW	SW	SW	W	W	W	W	W	W	W
	Velocity	----	----	----	----	----	----	----	----	----	19	20	20	17	13	19	20	21	30	38	38	35	31	33	31
Nov. 9	Direction	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	SW	----	----	----	----
	Velocity	33	34	36	41	40	40	42	41	40	33	28	26	25	26	24	23	23	20	20	11	----	----	----	----

While the above record of the November, 1913, storm was obtained at Cleveland, it is probable that it fairly represents conditions throughout the district. Its notable feature was the long duration of winds of very high velocity. For seven hours an average velocity of nearly 54 miles an hour was maintained, as compared with a maximum velocity of 50 miles per hour for a five-minute period during the storm of 1912.

The tremendous seas developed under these conditions unquestionably subjected harbor works in this vicinity to the most severe test in their history. It is therefore especially gratifying that the damage sustained by them was comparatively limited.

The harbors in this district were first improved and protected by jetties extending out from the mouths of the rivers, the lower portion of the river forming the harbor. Later on breakwaters were built, designed either to protect the entrances to the inner channels or to provide outer harbors of sufficient size to be used for shelter and for commercial development. The old piers and breakwaters are all of substantially the same design, namely, stone-filled timber cribs (Fig. 1). Such structures require very frequent repair, and in a comparatively short time become so badly decayed above the water line that the complete reconstruction of their upper sections is necessary. In many cases the original superstructures, beginning at a point about 3 feet below the water line, have been rebuilt with concrete. Some of the breakwaters have also been strengthened by the deposit of riprap along their outer

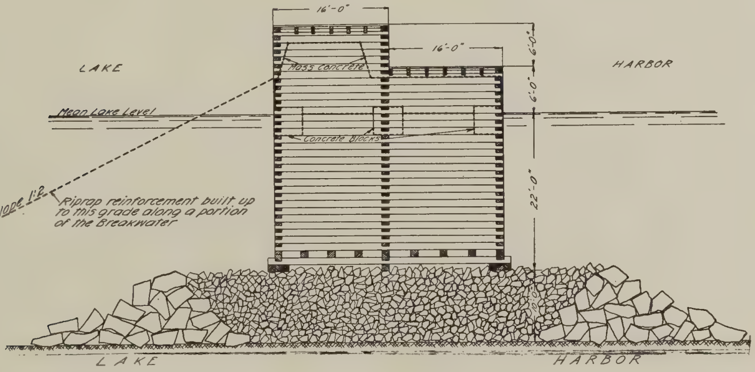


Fig. 1. Cleveland breakwater. Typical timber section. Method of rebuilding superstructure and reinforcing with riprap stone indicated by broken lines.

faces, an apparently effective method of reducing the destructive racking of these structures through the impact of seas.

In recent years its increasing scarcity and consequent high cost have resulted in the practical abandonment of the use of timber for breakwaters. The one other available material being stone which, in this vicinity, is abundant and cheap, there has been developed what is known as the "rubble mound" type of breakwater. As its name implies, it is essentially a mound or ridge of stone of considerable width at its base from which it gradually slopes up on both sides to a narrow top or deck. As at first designed (Fig. 2), the lower portion of the breakwater consisted of two ridges of heavy riprap which formed the toes of the structure and between which a core of sand was deposited to grade about 20 feet below mean lake level. A thin cushion of coarser material was interposed directly against the ridges, with a view to preventing the leakage of the sand. The core was then completed with coarser material, such as shale, and covered over with riprap. The riprap was carefully leveled off with small stone to form a bed for the outer covering or paving, which consisted of regular shaped blocks laid accurately to grade. It very soon became evident that, while theoretically economical, practically the use of sand was undesirable for two reasons: (1) It was difficult to retain it between the stone ridges without leakage, and (2) it filled the only portion of the section in which the quarry refuse, which accumulated rapidly in connection with getting out the paving stone, could be used. Aside from these considerations, it developed that where any large work was in progress it was exceed-

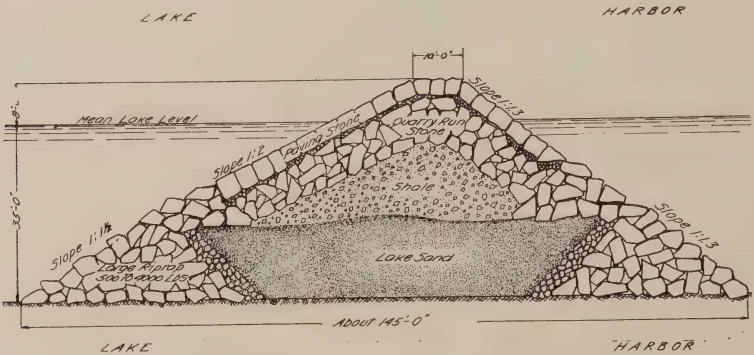


Fig. 2. Cleveland breakwater. Earliest type with sand core and smoothly paved surface.

ingly difficult to secure desirable sand in sufficient quantities at any reasonable cost. While there are large deposits of sand on the lake bottom they are usually of little depth in this vicinity. Near river mouths the sand is also intermixed with silt to an extent which renders it unfit for use. For these reasons a change in design was made which confined a comparatively small amount of sand to the middle of the section and replaced a large part of it by coarser material (Fig. 6). This coarser material was, for the most part, shale which is encountered in this vicinity at varying depths. As in the case of sand, however, the supply available at a low cost was limited. Wherever it could be obtained in connection with channel deepening operations its use was entirely practicable, but where it was dredged especially for the work and towed considerable distances no economy resulted. As now built the use of sand and shale has been entirely discontinued and the core is constructed of quarry run stone, or of a mixture of this material and quarry waste (Fig. 7).

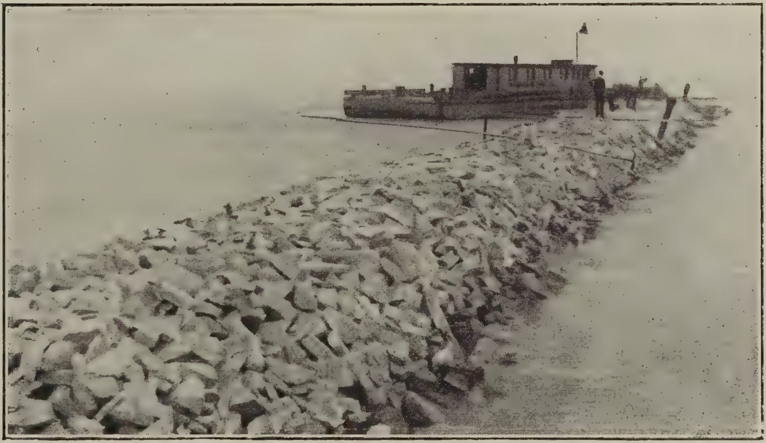


Fig. 3. The first type of rubble-mound breakwater at Cleveland. Bedding prepared for placing the paving.

The other important change in design has been the abandonment of the use of smooth paving and the adoption of a comparatively rough covering of quarry run stone. Two considerations have led to this change: (1) The very much higher cost of the smooth covering, and (2) its inherent weakness. Its higher cost was due not only to the greater difficulty in securing suitable stone, but also to the more expensive manner in which it was required to be placed.

It was often impossible during construction to set the paving immediately after the bed had been prepared to receive it, and it not infrequently happened that a heavy storm would wash out considerable quantities of the small stone with resultant loss to the contractor and delay to the work. It is also believed that the design was somewhat weak in that the stability of each stone depended so largely on the footing afforded it by the course immediately below. The displacement of a single stone was likely to result in damage to a considerable section of the covering, on account of its tendency to slide, and through the exposure and washing out of the bedding stone.

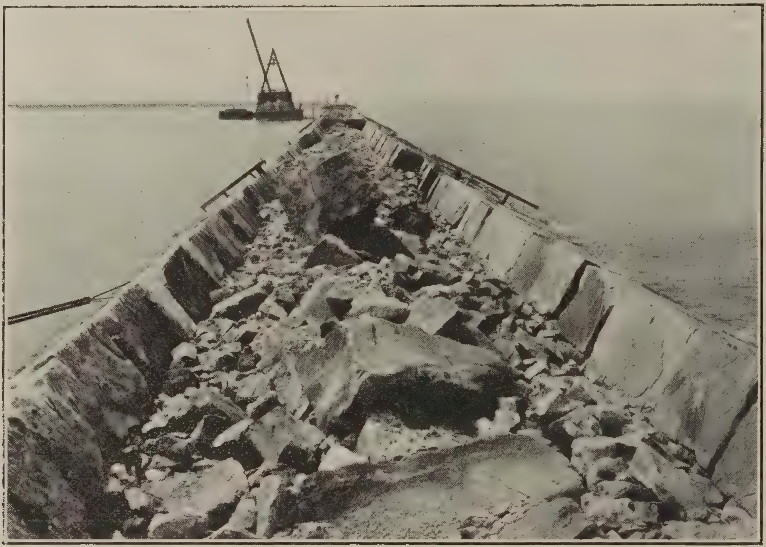


Fig. 4. The first type of rubble-mound breakwater at Cleveland. Side slopes laid.

For these reasons the use of smooth paving was discontinued, and for a short time the very roughest covering was employed. Little care was exercised in its placing beyond requiring that it consist of large stone placed without blocking or leveling and that the stones should extend at least 5 feet into the section. It was found, however, that little, if any, greater expense was involved and that more satisfactory results were obtained if by some selection of stone the covering were built up more compactly, as indicated in Fig. 4. This general design has therefore been followed in all recent structures. Its advantages are believed to be: (1) That it is economical, because no carefully quarried stone is required, and because the various sizes of stone are utilized in somewhat the same proportions as they are produced in ordinary quarrying operations; (2) that the danger from leakage of the core is eliminated; (3) that the covering is much more stable than in the first design, since it is bound into and made an integral part of the structure, and no serious results are likely to follow the disintegration or displacement of a single stone.

When built in the same depth of water, all of the types of breakwaters above described have cost approximately the same for equal lengths. This cost has amounted to about $175 per linear foot. Under present conditions, however, the cost of timber breakwater properly reinforced would probably be not less than $300 per linear foot, and it is likely that the particular type of smooth paved breakwater formerly built could not be duplicated at anything like the original prices. Considering not only the first cost but the subsequent maintenance charges, the present type of rubble mound breakwater is believed to be by far the cheapest as well as the most effective of any yet constructed.

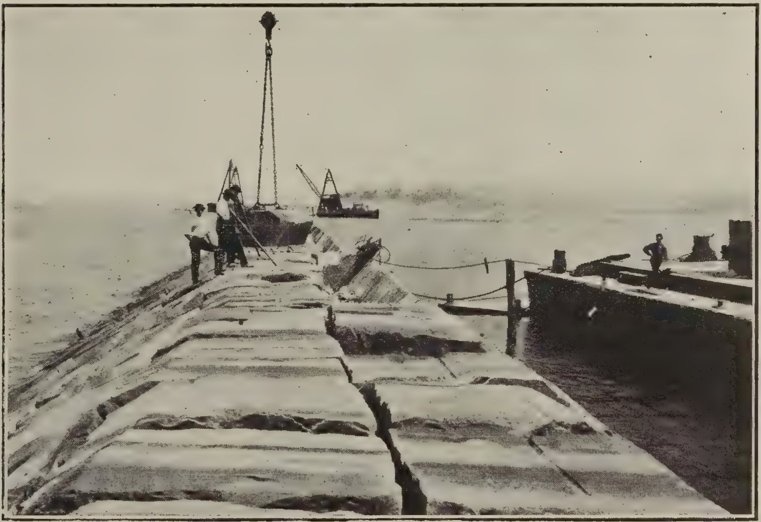


Fig. 5. The first type of rubble mound, Cleveland breakwater. A completed section.

The action of the storm of November, 1913, upon the various types of breakwaters above described may be stated as follows:

In general, out of a length of breakwaters and piers aggregating about 77,000 linear feet, but 3,230 feet were seriously damaged.

All of this serious damage occurred at Cleveland, where the following structures are located:

Kind.	Type.	Approximate length. Feet.	Damage.
Breakwaters	Timber, Concrete Superstructure	5,930	None.
Breakwaters	Timber, Wooden Superstructure, in poor condition	2,230	1,230 feet — Superstructure partially destroyed.
Breakwaters	Timber, Sloping Wooden Superstructure, in good condition	1,070	None.
Breakwaters	Smooth paved rubble	2,000	Superstructure stone displaced.
Breakwaters	Rough rubble	16,900	None.
Piers	Timber, Concrete Superstructure	1,850	None.

1. *Timber Breakwaters.* Except for those which have been entirely reconstructed, but a portion of one of the timber breakwaters in the district was in first-class condition at the time of the storm, and this portion was not damaged in any way. The damage to timber breakwaters which have been rebuilt with concrete superstructure was not appreciable. It is believed, however, that until such structures are properly protected with riprap along their exposed faces, each severe storm produces serious strains in them on account of the very heavy loads which they support, which will, in time, prove destructive. The timber breakwaters damaged were those which have not been kept in repair. Whenever these structures become decayed above the water line to such an extent that it is no longer practicable to keep them in good condition by ordinary repairs it is the practice to discontinue such repairs until the complete reconstruction of the upper section becomes necessary. This is regarded as the most economical method of maintenance. For this reason, several of this class of structures were in such a condition that they were very liable to damage by any severe storm. Two views are shown of the older portion of the east breakwater at Cleveland. As will be noted, much of the decking was destroyed and some of the outside and cross walls down to points at or near the water line were broken up and carried away. A considerable amount of the small stone with which the cribs are filled was also

washed out. This damage can not, however, be regarded as serious since it merely necessitates hastening repairs which would in any event be required in the near future.

2. *Rubble Mound Breakwaters.* All of the rubble-mound breakwaters in the district built according to the more recent design were unaffected by the storm beyond undergoing a slight settlement. This settlement was little more than a compacting of the covering, and in all probability increased rather than decreased the stability of the structures. The earlier type of rubble-mound built at Cleveland Harbor was, however, extensively damaged. As indicated in the accompanying views taken shortly after the storm, many of the covering stones were displaced and some were carried entirely outside of the section. The disruption of the covering was so extensive that in many places the core was exposed to the seas and a considerable quantity of the smaller stones of which it was composed was washed out. At one point this process had so far advanced that a partial breach was formed in the breakwater. The

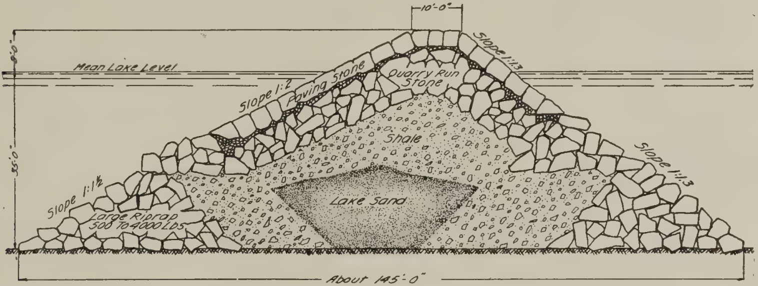

10'-0"
Slope 1:1.3
Mean Lake Level
8'-0"
Paving Stone
Quarry Run Stone
Slope 1:2
Shale
Slope 1:1.3
35'-0"
Slope 1:1½
Large Riprap 500 To 4000 Lbs.
Lake Sand
About 145'-0"

Fig. 6. Cleveland breakwater. First modification of design. Amount of sand in core greatly reduced.

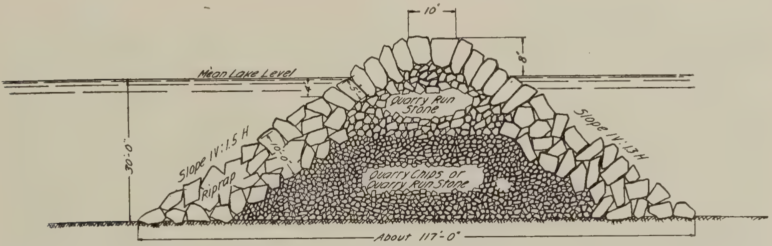

10'
8'
Mean Lake Level
4'
5'
Quarry Run Stone
Slope 1V:1.3H
Slope 1V:1.5 H
10'-0"
30'-0"
Riprap
Quarry Chips or Quarry Run Stone
About 117'-0"

Fig. 7. Cleveland breakwater. Design now followed. Sand omitted from core and rough instead of smooth covering.

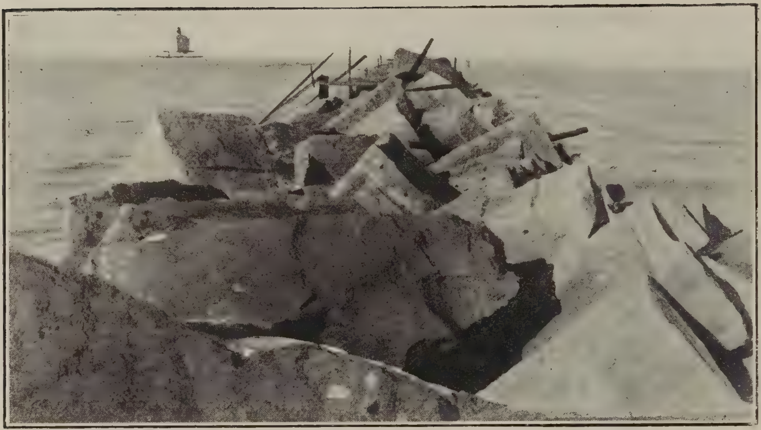


Fig. 8. Cleveland breakwater. The very rough type of covering used for a short time after the smooth paving was discontinued.

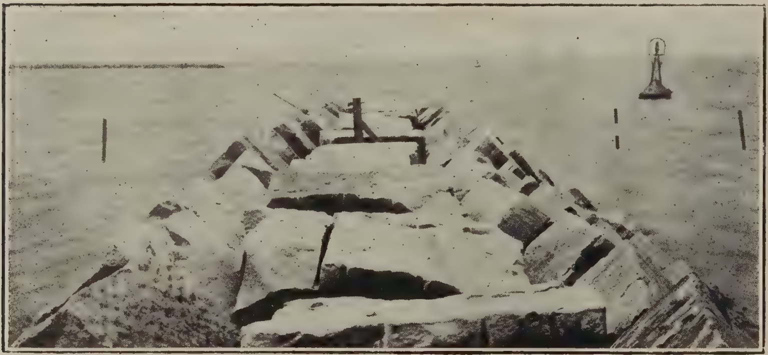


Fig. 9. The present Cleveland type of rubble-mound breakwater. In some places, by a more careful selection of the stones used in the deck, a more finished appearance is secured.

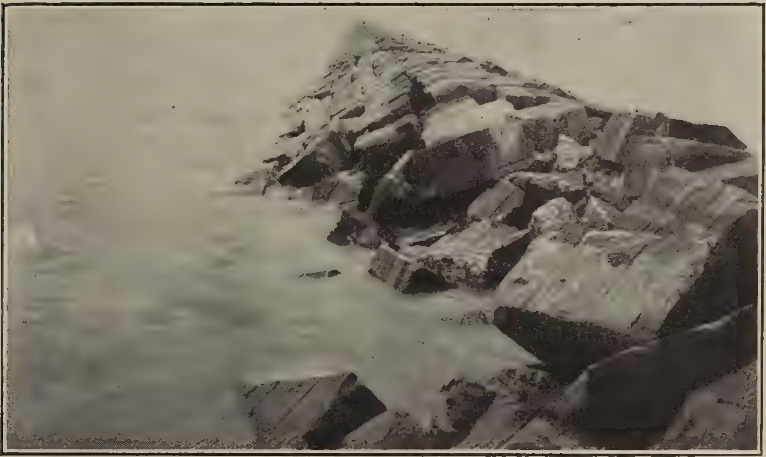


Fig. 10. View of the earlier type of rubble-mound breakwater, Cleveland; taken after the storm of November, 1913.

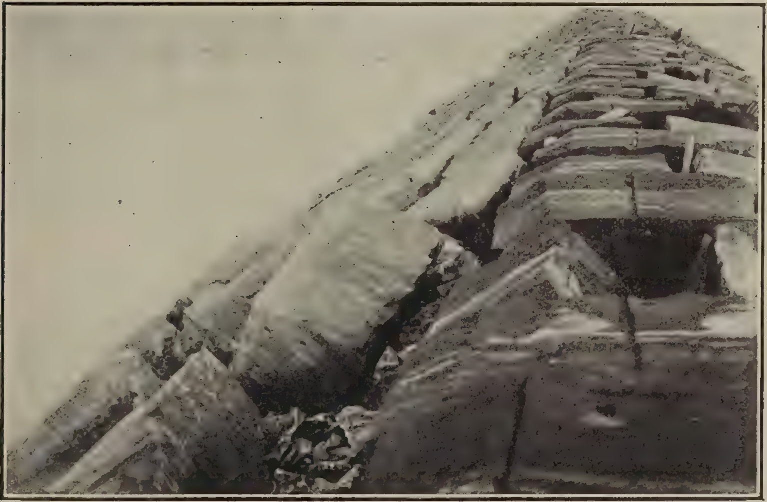


Fig. 11. View of the earlier type of rubble-mound breakwater, Cleveland Harbor, Ohio; taken after the storm of November, 1913. Rotating motion of paving stones can be noted.

motion in the covering stones was evidently a combined subsidence, sliding and rotation.

While the cause of failure is to a certain extent a matter of conjecture, the most plausible explanation appears to be found in the fact that the greatest damage occurred where the greatest amount of sand was used in the core. It is a reasonable theory that the failure was due to a leakage of this sand core, caused by the violence of the waves during the storm. As the sand settled, the upper ridges of heavy stone rotated toward the center of the section and, since these ridges form the footings for the paving blocks, their displacement eventually resulted in the conditions noted.

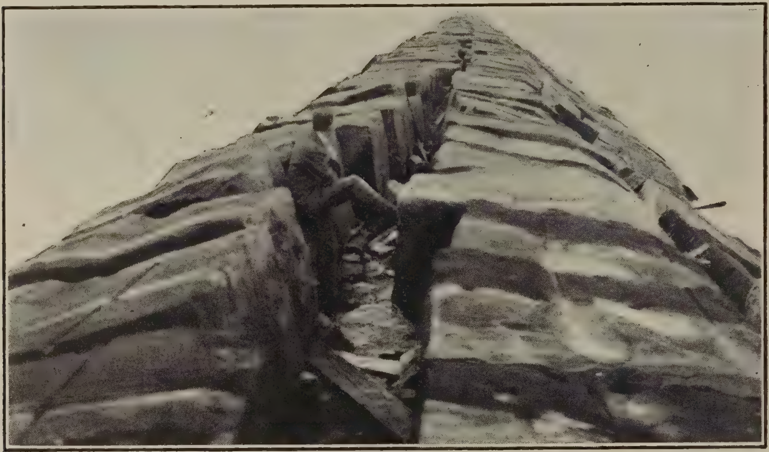


Fig. 12. View of the earlier type of rubble-mound breakwater, Cleveland Harbor, taken after the storm of November, 1913. The sliding motion of the paving stones is very evident.

Whatever may be the real fault of the early design, it is quite evident that it has been overcome in the later designs.

The only question now requiring consideration in this connection is that of the most advantageous manner of making repairs. Similar failures have occurred in the past though never to such a marked degree, and are likely to occur again in the future. Immediate repairs will be made by filling in the voids in the covering with large stone, and it is altogether likely that by continuing this process as the necessity for it arises, the structure will eventually be made permanent at comparatively little expense.

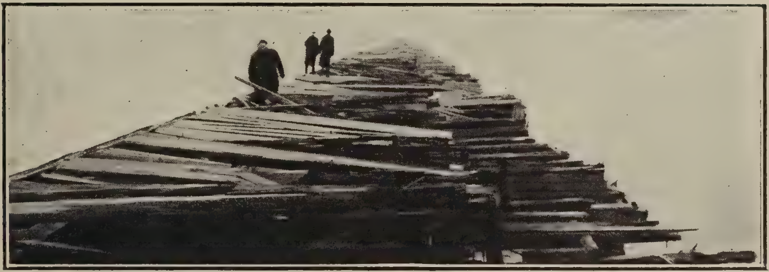


Fig. 13. A view along the old timber breakwater, Cleveland Harbor. Taken after the storm of November, 1913.

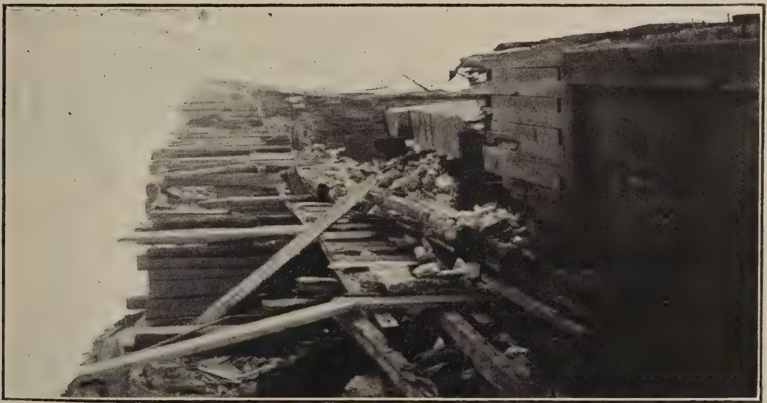


Fig. 14. A view along the old timber breakwater, Cleveland Harbor. Taken after the storm of November, 1913.

The Engineers With General Sherman's Army

Reports by Gen. O. M. POE, and by Maj. HUBBARD, Twelfth Missouri Cavalry, with introduction by Lieut. Col. W. E. CRAIGHILL, Corps of Engineers.

INTRODUCTION.

In order to understand the following reports, it is necessary to know the organization of the Army to which they belonged.

On May 1, 1864, on leaving Chattanooga for the campaign to Atlanta, it consisted of three armies, commanded by Thomas, McPherson, and Schofield. Their total strength in infantry, artillery, and cavalry was 98,797, distributed as follows:

Army of the Cumberland	60,773
Army of the Tennessee	24,445
Army of the Ohio	13,559

After leaving Atlanta for the march to Savannah and thence through the Carolinas, Sherman organized his column into two wings and the cavalry, which he kept under his own immediate orders.

At the beginning of the movement, on November 10, 1864, the total strength in infantry, cavalry, and artillery was 59,545:

Right Wing	27,082
Left Wing	27,448
Cavalry	5,015

Upon leaving Goldsborough, N. C., April 10, 1865, for the final march, which eventually ended at Washington, D. C., the strength was 88,948, divided into two wings and the center, with an independent cavalry division:

Right Wing, Army of Tennessee	28,834
Left Wing, Army of Georgia	28,063
Center, Army of Ohio	26,392
Cavalry	5,659

The report of Maj. James M. Hubbard,Twelfth Missouri Cavalry, commanding the pontoniers with Gen. James H. Wilson's cavalry column is interesting as showing what may be done by the ponton train on a forced march.

This train of twelve boats marched from Selma, Ala., to Macon, Ga., 306 miles, between April 11 and 21, inclusive, arriving with teams in good condition.

References in parenthesis in the reports are volumes and plates of rebellion records.

Report of Capt. Orlando M. Poe, Corps of Engineers, U. S. Army, Chief Engineer of General Sherman's Army, 1864-1865.

The Atlanta and Savannah Campaign and the Campaign of the Carolinas.

Washington, D. C., *October 8, 1865.*

Sir: In accordance with the circular from the Engineer Bureau, dated September 2, 1865, I have the honor to report as follows, concerning "the engineer operations and the works of attack and defense conducted under my superintendence during the year ending June 30, 1865:"

This report will naturally be divided into four parts, viz:

First. The Atlanta Campaign, from the 1st of July, 1864, to the occupation of the city, September 2, 1864.

Second. The new defenses of Atlanta and the Savannah Campaign, including the time from the 3d of September, 1864, to the 25th of January, 1865.

Third. The campaign from Savannah, Ga., to Goldsborough, N. C., from January 25, 1865, to March 22, 1865.

Fourth. The campaign from Goldsborough, N. C., to Raleigh, N. C., and the march from Raleigh to Washington City, from April 10, 1865, to 20th of May, 1865.

The operations connected with the march of General Sherman's army, extending over a great portion of the Southern States, were of a very rapid character. Such of them as legitimately belonged to the engineer department were so intimately blended with the whole that it is impossible to separate them. In order to explain clearly why bridges were built and roads made in the localities where they were, it will be necessary to give the movements of the army somewhat in detail when the reasons will generally be evident. The labors of the engineers were directed to facilitate these movements, and always with a distinct idea of their object.

First. The Atlanta Campaign, from the 1st of July, 1864, to the Occupation of the City, September 2, 1864.

On the 1st of July, 1864, I was on duty as chief engineer with the army commanded by Maj. Gen. W. T. Sherman, then before Kenesaw Mountain, a position to which I had been assigned by Special Field Orders, No. 1, headquarters Military Division of the Mississippi, dated Chattanooga, Tenn., May 3, 1864. At that time the engineer organization for the army in the field was altogether inadequate. There were within the limits of the military division the following engineer organizations,viz: First Michigan Engineers and Mechanics and First Missouri Engineers. Both these regiments belonged to the Army of the Cumberland, and were distributed as follows: The former along the railroads forming our lines of supply, engaged in building block-houses to defend them against raiding parties of the enemy's cavalry; and the latter along the important line of railroad from Nashville to Johnsonville on the Tennessee River, engaged in completing that work. The Department of the Ohio was provided with an engineer battalion, organized under my direction in 1863, when the movement upon East Tennessee commenced. Its organization was explained in my report upon that campaign.* It now accompanied the Army of the Ohio. The Department of the Tennessee was not provided with any regular engineer organization, but was fortunate in having an excellent pioneer organization. In order to equalize the engineer forces in the military division the major-general commanding, at my suggestion, transferred the First Missouri Engineers from the Department of the Cumberland to the Department of the Tennessee, and it was ordered to join the army in the field. Two ponton bridges, having an aggregate length of 1,400 feet, were with the forces in the field and distributed as follows: 800 feet, in charge of the Fifty-eighth Indiana Volunteer Infantry, commanded by Col. George P. Buell, were attached to the Army of the Cumberland; 600 feet, in charge of Captain Kossak, aide-de-camp, and a body of pioneers, were attached to the Army of the Tennessee. Both of these bridges were of the kind known as the "canvas bateau bridge." Two more bridges of the same kind, each 600 feet in length, were held in reserve at Nashville.

The staff organization of the engineer department with that army was as follows: Capt. O. M. Poe, U. S. Engineers, chief engineer Military Division of the Mississippi; Capt. C. B. Reese, Corps of

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(*See Vol. XXX, Part II, page 568.)

Engineers, chief engineer Department and Army of the Tennessee; Capt. W. J. Twining, lieutenant of engineers, chief engineer Department and Army of the Ohio; Lieut. H. C. Wharton, Corps of Engineers, chief engineer Army of the Cumberland. Until the early part of May the duties of chief engineer Army of the Cumberland had been performed by Capt. W. E. Merrill, Corps of Engineers, but he having received authority to organize the regiment of Veteran Volunteer Engineers provided for by act of Congress, had gone to Chattanooga for that purpose. Early in July the following officers of the Corps of Engineers, who had just graduated at West Point, reported to me, and were assigned to duty as follows: Capt. J. W. Barlow, to Army of the Tennessee; First Lieut. O. H. Ernst, to Army of the Tennessee; First Lieut. William Ludlow, to Army of the Cumberland; First Lieut. A. N. Damrell, to Army of the Ohio.

In the Army of the Cumberland each corps, division, and nearly every brigade was provided with an officer detailed from among the commissioned officers of the infantry regiments, whose duty it was to make such surveys and reconnaissances as might be wanted. The other two armies were not so well provided, but had sufficient organization to do all that was requisite.

The military operations of the previous two months had gradually forced the enemy from his position in Buzzard Roost Gap back to the ground he now held at Kenesaw Mountain. During this time the labors of the engineers were confined to reconnoitering, road making, and bridge building. Ponton bridges had been built over the Oostenaula, at Resaca, at Lays Ferry, and two flatboat bridges over the Coosawattee; also ponton bridges over the Etowah River at the cliffs.

The enemy showed little disposition to yield his stronghold at Kenesaw. After the assault of the 27th June it was determined to move toward our right, at the same time advancing that flank, a movement which it was supposed would result in the evacuation by the enemy of all ground north of the Chattahoochee except his bridge-head at the railroad crossing. Receiving instructions from General Sherman, commanding, I made a personal reconnaissance of the ground upon our right as far as our extreme cavalry outposts, at or near Andersons Mill or Olleys Creek, and immediately upon my return and report the Army of the Tennessee was put in motion. No sooner was this movement developed than the enemy, on the night of the 2d and morning of the 3d of July, evacuated his position at Kenesaw and in front of Marietta, and we took position, the troops moving right on in pursuit. Contrary to expectation and information, we found that the enemy intended to make a stand upon a line from Ruffs Station (Neal Dow) to Ruffs Mill, the flanks being refused along Nickajack and Rottenwood creeks. This line had been prepared by militia and contrabands only a few days before its occupation by Johnston's army, and was well built, consisting of good infantry parapets, connecting salients, in which were placed a large number of pieces of field artillery in embrasure. The length of this line was nearly 6 miles. On the 4th of July our skirmishers drove the enemy's into the works on the main road by a spirited dash, being supported by the divisions of Stanley, of the Fourth Corps, and Johnson, of the Fourteenth Corps, and our lines pressed up at all points, but not near enough to silence the artillery. Late in the evening the Sixteenth Corps, forming the left of the Army of the Tennessee, carried by assault a portion of the rebel line. At daylight on the morning of the 5th of July our skirmishers advanced, only to find the enemy gone, a movement rendered necessary upon their part by the success of the Sixteenth Corps on the evening previous.

The next line of works was found in front of the railroad bridge and the several roads and ponton bridges, at Paces, Montgomerys, and Turners ferries, forming a very extensive tete-de-pont, which consisted of a system of square redoubts, in defensive relations, connected by infantry parapets, but few of these redoubts were prepared for artillery, being arranged with a banquette for infantry fire. The artillery was placed in small intermediate redans. The redoubts partook more of the character of tambours. They were constructed by building double log-pens, and filling the space between them with earth. There was nothing in the plan to recommend them to the attention of the engineers. The left of this line rested upon a large seven-gun redoubt near the mouth of Nickajack Creek, and the right upon another redoubt prepared for eight guns, and situated near the Chattahoochee, about 1 mile above the railroad bridge. Opposite this point the intrenchments on the south side of the river began, and extended in a continuous line nearly to Island Creek, being altogether about 8 miles. The railroad bridge at its southern end was protected by three batteries of irregular shape, and one redoubt. This line, owing to the care bestowed upon its construction and the nature of the approaches, was by far the strongest we had yet encountered. It had been built for some length of time, and had been located by good engineers. A few days spent in reconnaissances showed us very plainly that it would cost many lives to carry the position by assault, even were an assault to succeed, which was extremely doubtful. It was accordingly deemed best to turn it. An inspection of the country showed us that this must be done by the left, since such a movement to right, owing to the broken character of the country, and the fact that the enemy, expecting us to move that way, had carefully guarded all the crossing places, was almost impossible.

Having decided to pass the river by our left, strong demonstrations were made upon our right to confirm the enemy in the impression that the movement was to be made in that direction, and that we would attempt to cross the river at some point below the mouth of Nickajack Creek. The points selected for the crossing were at Roswell Factory and Phillips (Ishams) Ferry, and the Army of the Tennessee, which had been demonstrating upon our right, was suddenly thrown to Roswell, where it crossed the Chattahoochee upon a trestle bridge, built by the pioneers of the Sixteenth Army Corps out of the materials at hand. No opposition was made by the enemy. The Army of the Ohio, which had been on the left, now became the center, made a rapid movement across the river at Phillips Ferry, surprising a small force of the enemy stationed there, and capturing one piece of artillery. While the force which actually effected the crossing was engaged in constructing some light works to serve as a bridge-head, two canvas ponton bridges were thrown, upon which the balance of the Army of the Ohio crossed.

I may make the general remark here that whenever it was deemed necessary to use a bridge for a greater length of time than forty-eight hours the ponton bridges were invariably replaced by wooden trestle bridges constructed from the materials at hand, either by engineer troops or the pioneer force. The object of this was to preserve the canvas covers of the bateaux, even at the expense of considerable labor, since we had the latter in greater abundance than the former.

The canvas bridges at Phillips Ferry were replaced by a trestle bridge built by the Engineer Battalion of the Twenty-third Army Corps. Another ponton bridge was thrown meanwhile at Powers Ferry, some 2 miles lower down, upon which the Fourth Army Corps crossed. This corps formed a junction with the Army of the Ohio, but the Army of the Tennessee was still acting independently. One division of the Fourth Corps now swept down the south bank of the River to Paces Ferry, which enabled us to build two ponton bridges at this point, upon which the Fourteenth and Twentieth Corps crossed. Two days before this the enemy, under influence of the presence of the Fourth and Twenty-third Corps, on the south side of the river, had crossed his whole force to that side, and left us in possession of the strong line on the north side, upon which so much care and labor had been bestowed. The passage of the Chattahoochee had now been completely effected. Our whole army was on the south side of the river, with a loss of less than a dozen men, but between us and Atlanta, our objective, were still the three serious obstacles of Nancys Creek, Peach Tree Creek, and the entire rebel army. We knew but little about the country, and the inhabitants, always few in number and indisposed to give us information, had all gone farther south. Not an able-bodied man was to be found between Marietta and the enemy's line. We could only feel our way cautiously forward, using the greatest diligence in reconnaissances. The Army of the Tennessee, forming the left wing, was directed toward Stone Mountain; the Army of the Ohio, in the center, toward Cross Keys and Decatur, and the Army of the Cumberland, on the right, via Buck Head, toward Atlanta. The left wing and the center crossed Nancys Creek the same day, July 18. The cavalry division of General Garrard, which had been operating on the extreme left, succeeded in reaching the Augusta railroad between Decatur and Stone Mountain. On the next day, July 19, the Twenty-third Army Corps, after a sharp skirmish, occupied Decatur, where it formed a junction with the Army of the Tennessee. The Army of the Ohio then withdrew, and passing to the right camped for the night on Pea Vine Creek. The Army of the Cumberland crossed a small force over Peach Tree Creek, which maintained its footing.

July 20, the Army of the Tennessee advanced along the Augusta railroad to within about 3½ miles of Atlanta, where the enemy was found intrenched. The Army of the Ohio moved along the road leading from Judge Peyton's to Atlanta, and soon encountered the enemy intrenched. The Army of the Cumberland crossed Peach Tree Creek at several points, and the left of it (Fourth Corps), connecting with the Army of the Ohio, met the same obstacle. The Fourteenth Corps, on the extreme right, moving on the Howells Mill Road, joined the Twentieth Corps on its left, and this, in turn, joined Newton's division, of the Fourth

Corps, which was moving on the Colliers Mill Road. There was no communication on the south side of Peach Tree Creek between Newton's and the other divisions of the Fourth Corps. This was the status when two rebel corps moving down the Howells Mill Road and Colliers Mill Road attacked the Twentieth Corps,together with the left division of the Fourteenth Corps and Newton's division. After a severe engagement, lasting until dark, the enemy was repulsed at all points. The result was to firmly establish our position on the south bank of Peach Tree Creek, having overcome two of the three obstacles already referred to as between us and Atlanta.

July 21, we steadily pressed forward along our whole line, developing the enemy in his intrenchments, extending from a point about a mile south of the Augusta railroad around the north side of the city to the Chattanooga railroad. This line was well built, and capable of a tolerably good defense. It consisted of a system of open batteries for artillery connected by the usual infantry parapet, with all the accessories of abatis, chevaux-de-frise, etc. But it was evidently not the main line upon which the enemy relied for his final defense.

July 22, the enemy evacuated the line referred to above during the night of the 21st, and we pressed forward on all the roads until the enemy was again found behind intrenchments. Reconnaissances proved that these were finally the main lines of defensive works covering Atlanta. They completely encircled the city at a distance of about 1½ miles from the center and consisted of a system of batteries open to the rear and connected by infantry parapet, with complete abatis, in some places in three and four rows, with rows of pointed stakes, and long lines of chevaux-de-frise. In many places rows of palisading were planted along the foot of the exterior slope of the infantry parapet with sufficient opening between the timbers to permit the infantry fire, if carefully delivered, to pass freely through but not sufficient to permit a person to pass through, and having a height of 12 to 14 feet. The ground in front of these palisades or stockades was always completely swept by the fire from the adjacent batteries, which enabled a very small force to hold them. To this line we opposed another, extending from a point 1½ miles south of the Augusta railroad around by the north to a point 1½ miles southwest from the 3-mile post on the Atlanta and Chattanooga Railroad. About noon, while engaged in extending this line to the left and front, the enemy, making a detour to the south and eastward, passed around our left flank and, completely enveloping it, attacked it both in flank and rear. Fortunately the Sixteenth Corps was en route to meet just such an attack, and was in a position to form looking to our left rear, its right joining the Seventeenth Army Corps. The fighting here was of the most desperate character. Meanwhile, the enemy pushed one corps from their works right down the Augusta railroad upon our line, where they gained a temporary success, but were finally driven back at all points. Our troops now were put under the cover of the ordinary rifle trenches, with works of a slightly heavier character for the artillery.

Close reconnaissances were made of the enemy's whole line in our front and it was decided that no attempt at assault should be made upon that part of the enemy's line which we could see. On the 23d of July I talked with the major-general commanding, and from him I learned that no assault would be made at present, neither did he desire anything like regular siege operations, but instructed me to see that the lines occupied by our troops were of such a character that they could be held against a sortie, and to put them forward at all points where it could be conveniently done, at the same time informing me that he would attempt to reach the enemy's line of railroad communication, at or near East Point, the junction of the roads from West Point and Macon to Atlanta. It is about 6 miles southwest from Atlanta. This movement he hoped would either result in a general engagement, with the chances greatly in our favor, or in the evacuation of Atlanta. He directed me to personally select a line at the Augusta railroad where our left flank could rest and command that road, while the Army of the Tennessee was withdrawn to make the movement indicated. On the morning of the 24th of July, accompanied by Capts. C. B. Reese and J. W. Barlow and Lieuts. Twining and Ernst, of the Corps of Engineers, I passed over the ground, selected the line, and gave the necessary directions for its construction. General Sherman having determined to send a cavalry force around each flank of the enemy to operate upon his communication, I was directed to see in person to the construction of a ponton bridge at Turners Ferry. This was done by ordering the train belonging to the Army of the Tennessee from where it was then laid, at the railroad crossing over the Chattahoochee, via the old Peach Tree Road to Turners Ferry. After proceeding as far as Proctors Creek, we found that the enemy occupied Turners Ferry.

It was then too late to do anything toward fighting for possession of the ferry, and I did not have a single armed man with me, even if there had been time. Upon a report of the facts to General Sherman, he ordered the cavalry division of General McCook to clear the ground at daybreak next morning, July 26, which was done, the bridge constructed, and communication established between the cavalry forces on the south bank of the river with those on the north bank.

The new line to be occupied by our left flank, upon the withdrawal of the Army of the Tennessee, having been completed by the morning of the 27th of July, the movement of that command toward our right flank commenced, and at the same time the movement of the cavalry forces began; that passing around the enemy's left flank being under the command of General McCook, and that around his right flank under General Stoneman and Garrard, the balance of our army meanwhile pressing forward and gaining ground as rapidly as possible. This was continued on the 28th of July, when, at about noon, a furious attack was made upon the Army of the Tennessee, particularly upon the Fifteenth Corps, by a force of the enemy which moved from Atlanta out on the Lick Skillet Road. The whole of the Fifteenth Corps had been refused along a ridge extending northwestwardly from Ezra Church, and nearly parallel with the Lick Skillet Road, its left joining the Seventeenth Corps and making nearly a right angle with it near the church. The position was a most admirable one, and the enemy was severely whipped.

The rebel army in our front had been under command of Joseph E. Johnston until the 19th of July, when the command was transferred to General Hood. Johnston's policy appeared to be a purely defensive one. Hood's was decidedly offensive-defensive, as shown by the fact that three desperate and severe battles were fought within ten days after he assumed command.

The last three days of July were devoted to skirmishing to attain positions as favorable as possible. Meanwhile, under instructions from the major-general commanding, I selected a new line to be occupied as a flank by a portion of the Army of the Cumberland, in case it was decided to transfer the Army of the Ohio to the right flank. The line was constructed under the superintendence of Lieutenant Wharton, U. S. Engineers, after it had been fully discussed between Lieutenant Wharton, Twining, and myself. It extended from our front line near Walker's house, on the Colliers

Mill (Buck Head) Road nearly due north, to the line of rebel works evacuated on the night of the 21st of July.

On the night of the 1st of August the Army of the Ohio was withdrawn from its position on the left, and rapidly moved to the right near the poor-house and extending nearly to the north branch of Utoy Creek at Willis Mill, the engineers giving general directions concerning the lines. I rode over their whole extent in person.

August 2, the Army of the Tennessee swung forward its extreme right, about half a mile, turning upon its position at Ezra Church as a pivot. The Army of the Ohio connected with the right of the Army of the Tennessee. This movement developed a part of the enemy's line in front of these two armies, and discovered the same system of batteries, connected by infantry curtains, that we had met before, thus showing that we had not yet found the enemy's left flank, the prime object of all our movements.

August 3, a portion of the Army of the Ohio was thrown across Utoy Creek, and established itself on the south side without much opposition.

August 4, an attack was ordered to be made at 3 p. m. by the Army of the Ohio, and the Fourteenth Corps, of the Army of the Cumberland, the object being to thrust our forces through our lines, and effect a lodgment on the railroad between Atlanta and East Point. The attack, however, was not made.

August 5, the Chattahoochee River railroad bridge was completed, and our trains ran up to 3-mile post. By General Sherman's direction, I sent Lieutenant Ernst to Marietta to superintend the construction of defenses at that place. An attack was ordered for 2 p. m., the object being as given above, but again no attack was made.

August 6, the attack, twice before ordered, was made, but repulsed. The two corps of the Army of the Cumberland, forming the left of our Army, kept steadily pushing forward, but without anything like siege approaches. Our sharpshooters had gained such positions as rendered it difficult for the enemy to work his guns.

August 7, the attack made yesterday was renewed, and proved successful. It was found that the line of rifle trenches carried by the assault was not the enemy's main line, but stood nearly perpendicularly to it. The Army of the Tennessee moved forward about 400 yards, swinging upon the center of its right wing as a pivot. The successful advances, either directly or by swing upon some part of the line as a pivot, were made in the following manner: by pushing forward, just before daylight, a strong line of skirmishers to the position chosen beforehand, which maintained its ground during the day, each man getting such cover as he could, generally by scooping out a rifle-pit at the foot of a tree, behind a log or stone, in which they could find shelter. As soon as night made it possible, working parties were thrown out to the skirmish line and connected by the ordinary rifle trenches the entire chain of rifle-pits. These lines were continually being strengthened until it was desired to make another advance, when the operation was repeated. In this way our lines were pushed at any point we wished to within 200 yards of the enemy's and with slight loss. I wish here to impress upon the Engineer Department the fact that nothing like regular siege approaches were attempted. I frequently informed the general commanding that we could easily, at any time, push forward saps and pierce the enemy's lines, yet when we had done so we would have accomplished very little, since the enemy would take the precaution to construct another a few yards in his rear. The general, understanding this perfectly, always told me that he did not wish anything of the kind done, that he intended to gain possession of Atlanta by operating upon the enemy's lines of communication, until he either brought on a general engagement, in which event he expected to gain a decisive victory, or compel the enemy to evacuate the city, which he could easily do, as the place was not, and it was evident that it could not be, completely invested.

August 8 and 9, was at work everywhere strengthening our lines. Commenced the construction of batteries for four ½-inch guns which had been ordered. These were placed in position as follows: Two in front of the Twentieth Army Corps, near the Chattanooga railroad, and two others in front of the Sixteenth Corps. The whole of the Army of the Tennessee advanced about three-eighths of a mile in the manner already described, and the lines of the Army of the Cumberland were straightened, so the whole line was as far advanced as the salients had been. The Army of the Ohio was engaged in intrenching itself in its position south of Utoy Creek.

August 10, 11, and 12, no advances were made.

August 13, it was decided to move all the army, except one corps (which was to be thrown back to the Chattahoochee railroad bridge), around Atlanta upon the railroads running south from East Point, and the ponton train of the Army of the Cumberland was moved from the railroad bridge, along the north side of the river, to the Sandtown Ferry preparatory to throwing a bridge across the river at that point.

August 14, nothing was done by the engineer department, waiting further instructions.

August 15, the line of Proctors Creek was examined for the purpose of selecting a defensive flank to be used when the Army of the Cumberland was withdrawn. Two ponton bridges were laid at Sandtown Ferry.

August 16, accompanied by Lieutenants Twining and Damrell, I visited our extreme right and rode over the lines of the Army of the Ohio, as well as the position which Lieutenant Twining had already selected south of Utoy Creek to be occupied by the Army of the Ohio upon the withdrawal of the Armies of the Tennessee and the Cumberland. The position was admirably chosen. A trestle bridge was commenced at Sandtown Ferry to replace the ponton bridges at that point.

August 17, orders for the movement of the army to the rear of East Point were promulgated. The cavalry command of General Kilpatrick started upon a raid to the southward of Atlanta.

August 18 and 19, the troops kept hard at work to induce the enemy to believe that we contemplated no movement upon his rear of greater importance than a cavalry raid. The entire force of engineer officers hard at work reconnoitering all the roads to our right as far as the enemy's cavalry would permit.

August 20, a force of infantry reached the Atlanta and West Point Railroad near Red Oak Station, and tore up a portion of the track. Our batteries were completed along our whole line and we were ready for any emergency.

August 21 and 22, the pioneer force was all kept at work preparing siege materials. The batteries along our whole line kept up a slow but steady fire both upon the enemy's lines and upon the city of Atlanta. The remarks in this paragraph apply to every day for the last two weeks.

August 23, under instructions from the major-general commanding, I went to the Chattahoochee railroad bridge and selected a line to be occupied by the corps (Twentieth), which was to be left behind during our movements to the rear of Atlanta, and gave Lieutenant Ludlow full instructions concerning the building of it. The position held by the Fifteenth Army Corps during the battle of the 28th of July was selected by Captain Reese as a flank to be occupied by the Army of the Tennessee upon the withdrawal of the Army of the Cumberland. General Kilpatrick's cavalry command returned, having passed entirely around Atlanta.

August 24, at work upon the new flank referred to above. Reconnaissances pushed to the right almost as far as Campbellton.

August 25, at midnight, the grand movement commenced by the withdrawal of the Fourth and Twentieth corps. The latter marched directly to the railroad bridge, Paces and Turners ferries, while the former passing in rear of the Army of the Tennessee, bivouacked next night on Utoy Creek. Before the movement began its left had rested on the Decatur Road.

August 26, the movement of the Army of the Cumberland still going on, and at dark the left wing of the Army of the Tennessee was swung to the rear upon its right and occupied the position previously prepared for it.

August 27, all the army in motion except the Army of the Ohio. The Army of the Cumberland was placed in position along Camp Creek, covering all the roads leading from Mount Gilead Church toward East Point and Red Oak. The Army of the Tennessee was thrown farther to the right, but close enough to keep up communication. It covered all the roads leading toward Fairburn. But little resistance was offered to our advance. The troops intrenched their position every night. This was made a rule from the time the campaign commenced, and was continued until the close of the war whenever the proximity of the enemy rendered it prudent. I may add, also, that during all the operations of this great army, extending over a year of time and thousands of miles of territory, it was never surprised.

August 28, the Army of the Cumberland was thrown forward upon the Atlanta and West Point Railroad at Red Oak, and the Army of the Tennessee at Shadna Church and Fairburn, while the Army of the Ohio was thrown into such a position along the road from Mount Gilead Church to Red Oak as to cover our left flank. Immediately upon striking the railroad the troops were intrenched and without the loss of a dozen men we had secure hold upon it, and could proceed to destroy it as leisurely as we pleased.

August 29, the greater part of the army was at work destroying the railroad, which was effectually done for about 12½ miles, every tie being burned and every rail bent. The enemy did not attempt to disturb us.

August 30, the army again in motion, being directed as follows: The Army of the Ohio toward Morrows Mill, the Army of the Cumberland toward Couch's farm-house, and the Army of the

Tennessee toward the Renfroe place. The latter pushed on still farther and succeeded in seizing the Flint River Bridge and gaining a foothold between the river and Jonesborough. The enemy was found in force, covering the town.

August 31, the Army of the Ohio moved toward a point on the Macon railroad 2 miles south of Rough and Ready Station, and succeeded in reaching it, and, making a secure lodgment, intrenched. The Fourth Corps was put in position in support. Four more brigades of the Army of the Cumberland moved from Couchs due east, until they struck the railroad between the Army of the Ohio and Jonesborough, when they also intrenched. About the same time that these forces reached the railroad, the enemy attacked the lines of the Army of the Tennessee immediately in front of Jonesborough and tried to carry them by assault. They were repulsed with heavy loss

It was reported to me by Captain Reese that the First Missouri Engineers, which had been transferred at my request from the Army of the Cumberland to the Army of the Tennessee, had just joined the forces in the field, and were available for duty. This was the first regularly organized engineer regiment to join the army at the front.

September 1, the Army of the Cumberland was concentrated so as to connect from the left of the Army of the Tennessee to the railroad, about 2 miles north of Jonesborough, the Fourth Army Corps destroying the railroad as it advanced. The Army of the Ohio commenced the destruction of the railroad at Rough and Ready, and connected with the break made by the other troops. About 4 p. m. the Fourteenth Army Corps assaulted and carried the right of the enemy's line, consisting of the usual batteries connected by infantry parapet. The approach of night alone prevented the capture of the entire rebel force. We were now squarely upon the rebel lines of supply. The movements of our army had been so rapid that the enemy exhibited the greatest confusion, and shortly after midnight the light of the burning buildings and explosions of ammunition in the direction of Atlanta (distant 20 miles) indicated very plainly that the enemy was evacuating the place, and on the morning of the 2d of September the Twentieth Army Corps, which had been left behind at the Chattahoochee Bridge for the purpose, marched into Atlanta.

In describing these operations I have gone somewhat into detail, in order that they might be clearly understood, deeming it peculiarly the province of the engineer to call attention to such brilliant maneuvers as those which enabled us to pass a river, too deep to be forded, in the very face of the enemy with a loss of less than a platoon of men, and those which placed six army corps upon the enemy's lines of communication, in opposition to a single corps.

In accomplishing these results the engineer department performed the following special labor, viz: Ten ponton bridges built across the Chattahoochee River, averaging 350 feet in length, 3,500 feet; seven trestle bridges, built out of material cut from the bank across the same stream, of which five were double-tracked, and two were single, 350 feet long each, 2,450 feet; 50 miles (estimated) of infantry parapet, with a corresponding length of artillery epaulement; six bridges over Peach Tree Creek, averaging 80 feet long each, 480 feet; five bridges over Flint River, averaging 80 feet long each, 400 feet; also many smaller bridges built and many miles of road repaired. The topographical branch of the engineer department worked efficiently. Surveys were made of all the routes passed over by infantry columns, together with the lines of parapet built. A map on the scale of 4 inches to 1 mile illustrating the siege, so called, of Atlanta, has been forwarded to the Engineer Bureau, in which these surveys are compiled, from the passage of Peach Tree Creek, July 19, to the beginning of the movement upon the enemy's lines of communication. August 25, and a general map, photographic copy, illustrating the entire campaign from Chattanooga to Atlanta. I have also forwarded to the Bureau a complete set of photographic views, illustrating military operations about Atlanta.*

From the map department, 4,000 copies of campaign maps were issued to the proper officers to facilitate military operations. I desire to bear testimony to the efficiency of the engineer officers on duty with General Sherman's army. Though all have done well, yet I am particularly indebted to Capt. C. B. Reese and Lieutenants Wharton and Twining.

I can only return my thanks to those officers of volunteers who did nearly all the topographical work. They did their duty and did it well. I must leave to the chief engineers of the several armies to which they belonged to do them justice.

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*(Maps and views here mentioned to appear in the Atlas.)

Second. The New Defenses of Atlanta, and the Savannah Campaign, including the time from the 3d of September, 1864, to the 25th of January, 1865.

Upon our occupation of the city of Atlanta, acting under instructions from the major-general commanding, I made an examination of the lines occupied by the enemy during the so-called "siege," with a view to their modification for the use of our forces. Their development was found to be about 12 miles and was considered greater than could be held by such a force as would, in any event, be left as the garrison. I made further examinations of the ground interior to the old rebel lines to ascertain whether new lines of much shorter development could not be located, and selected a system of heights nearest the center of the city. This line was less than 3 miles in extent, but passed through the northern part of the town, rendering the destruction of a great many buildings necessary. The general commanding ordered the adoption of this line and directed the work to proceed, but subsequently suspended the operation of the order until greater necessity should arise.

Meanwhile, every effort was being made to increase the efficiency of the engineer organization. The chief engineer of the Army of the Cumberland was directed to take the necessary steps to have the First Michigan Engineers and Mechanics ordered to the front. This regiment, or rather eight companies of it, arrived at Atlanta about the last of September. Two more companies subsequently joined, but the remaining two companies did not reach the regiment for some months.

The major-general commanding having directed that the new line of fortifications be proceeded with, the entire engineer force was set at work to construct the profiles and revetments. General Corse, then commanding at Rome, Ga., on the 29th of September, made an urgent requisition for an engineer officer to examine and improve the defenses of that town. Lieut. William Ludlow, Corps of Engineers, was sent.

The first infantry details for work on the fortifications were called for on the 3d of October, and numbered 2,000 men. On the 5th of October I telegraphed to General Sherman, then at Big Shanty, as follows:

> The new line of works is in a defensible condition from the redoubt where the photographs were taken (Redoubt No. 7) around to the prolongation of the same street eastward. I have positions

completely finished this evening for thirty guns; the platforms are laid and the embrasures revetted for that number, and I can finish quite a number more to-morrow.

The line represented as in a defensible condition was on the south side of the town and nearly 2 miles in length; the labor upon it was all done by the two regiments of engineer troops and infantry details from the Twentieth Army Corps, the balance of the army then being in motion against the rebel army, which had appeared upon our lines of communications.

Work upon these new defenses continued until stopped, about the 1st of November, though after the first week the details from the infantry commands were much smaller, and the work progressed more slowly owing to this fact, as well as because the impression prevailed that they would not be wanted for our purposes. Much care had been bestowed upon the several redoubts, and the finish put upon each was excellent. Those numbered from 7 to 12, inclusive, were provided with mantelets from the embrasures; these were made both of rope and of boiler iron, and were of such a shape that they completely closed the embrasure when the gun was "from battery."

A complete set of photographs* illustrating these defenses has been forwarded to the Engineer Bureau, and they are projected upon the map illustrating the siege of Atlanta.

Early in November the preparations for the march to Savannah were completed and everything held in readiness therefor. Under directions from the major-general commanding, engineer orders were issued making the proper assignment of engineer troops and bridge trains.

Meanwhile a freshet in the Chattahoochee carried away all our trestle bridges, and such as were necessary for the passage of the army on its return to Atlanta were relaid from the ponton trains. They were put down, two at the Chattahoochee railroad bridge and one at Turners Ferry.

The engineer organization for the march to Savannah was as follows:

First. Engineer troops and troops of the line on engineer duty: (1) First Regiment Michigan Engineers and Mechanics, Col. J. B.

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*(To appear in the Atlas.)

Yates, unassigned, receiving orders direct from headquarters Military Division of the Mississippi, ten companies, 1,500 men. (2) First Missouri Engineers, Lieut. Col. William Tweeddale, in charge of ponton train with Right Wing (Army of the Tennessee), five companies, 500 men. (3) Fifty-eighth Regiment Indiana Volunteer Infantry, Col. George P. Buell, in charge of the ponton train of Left Wing, ten companies, 775 men. Total, 2,775 men.

Second. Pioneers: Left Wing, six divisions, each having a pioneer corps of the average strength of 100 men, 600 men; Right Wing, seven divisions, each having a pioneer corps of the average strength of 100 whites and 70 negroes, 1,200 men; total, 1,800 men.

Recapitulation: Engineer troops and troops of the line doing engineer duty, 2,775 men; pioneers, 1,800 men; aggregate for engineer duty, 4,575 men.

Third. Tools and tool trains: Each of the pioneer corps carried a sufficient number of tools to work their full strength, and in the Right Wing they were supplied with a duplicate set, which were carried in wagons. In the Left Wing each brigade was provided with a tool wagon, loaded with about 350 intrenching tools. A great many axes and shovels were in the hands of the troops, but always within reach in case of emergency. The Michigan Engineers and Mechanics had a train of fifty wagons, of which twenty were loaded with tools, as follows: 1,500 axes and helves, 1,500 shovels, 700 picks and helves, 200 hatchets, and an ample supply of carpenters' and bridge building tools, and extra saws and augers; also 100 hooks which I had devised for twisting railroad iron. The remainder of the wagons carried subsistence and quartermaster's stores. The Missouri Engineers has a much smaller train, which was somewhat mixed up with the ponton train of which they had charge. They carried the following intrenching tools: 500 shovels, 500 axes; also, an assortment of carpenters' and blacksmiths' tools.

Fourth. Ponton trains: Left Wing—pontoniers, Fifty-eighth Regiment Indiana Volunteer Infantry, Col. George P. Buell, commanding, 775 men. Materials: 51 canvas ponton boats, complete, 15 extra covers, 10 anchors, 2,000 pounds rope, 37 horses, 505 mules, 94 wagons, 3 ambulances, 2 tool wagons, 3 forges, 850 chesses, 196 balks, and the necessary harness, etc., to make the outfit complete. This regiment carried its own supplies of subsistence and forage on the wagons in the above list. The length of bridge which could be built from this train by cutting small timber for the balk was 850 feet. Right Wing—pontoniers, First Missouri Engineers, Lieut. Col. William Tweeddale commanding; strength, 530 men. Materials: 28 canvas ponton boats complete, 28 boat wagons, 600 chesses, 15 chess-wagons, 196 claw balks, 1 forge, 1 battery wagon, 2 tool wagons (a general assortment), 7 forage wagons, and a sufficient quantity of harness, rope, etc. Length of bridge, 580 feet; total length of bridges, 1,430 feet.

The foregoing was the engineer organization and equipment which was considered sufficient to make the campaign which I knew would be made to Savannah.

On the 7th of November I received a telegram from General Sherman directing me to take charge of the destruction of the railroads, depots, steam machinery, etc., in the city of Atlanta. On the 9th I telegraphed as follows: "I am all ready to do the work assigned me, and will act the instant I get your order to do so." I had called together the comanding officers of the engineer regiments and explained to them just what I wanted done, and we had selected the buildings and works for destruction. On the morning of the 12th General Sherman directed me to proceed with my work, but to be careful not to use fire, which would endanger other buildings than those set apart for destruction. The engineer regiments were divided into detachments, under picked officers, each of whom received a written order as follows:

> You will please take the detachment now under your orders to the first high chimney (stating locality and buildings) and throw it down, and continue the work along (stating the route) until you reach (the point designated as the limit of work for this detachment), being careful not to use fire in doing the work, since it would endanger buildings which it is not intended to destroy.

These orders were faithfully carried out, and neither fire nor powder was used for destroying buildings until after they had been put in ruins by battering down the walls, throwing down smokestacks, breaking up furnace arches, knocking steam machinery to pieces, and punching all boilers full of holes. The railroads within the limits of the old rebel defenses were destroyed by tearing up the iron, piling up the ties and after putting the rails across them firing the wood, which heated the iron, and then the rails were twisted. The rails were torn up by using a small but very strong iron "cant hook," devised by myself, and after they were heated were twisted by applying the same hooks at each end of each rail and twisting the iron bar around its horizontal axis, being careful to give the rail at least a half turn. The length of railroad destroyed in this manner, within the limits indicated above, was about 10 miles. The depots, car sheds, machine shops, and water tanks were also destroyed.

It was not until the evening of the 15th of November that fire was applied to the heaps of rubbish we had made. I was upon the ground in person to see that the work was done in a proper and orderly manner; and, so far as engineer troops were concerned, this was the case. But many buildings in the business part of the city were destroyed by lawless persons, who, by sneaking around in blind alleys, succeeded in firing many houses which it was not intended to touch.

Three army corps moved on the morning of the 15th of November, striking boldly out toward the sea. On the morning of the 16th the other army corps and the headquarters military division moved. The map* forwarded to the Bureau of Engineers with my letter dated Goldsborough, N. C., April 7, 1865, will indicate the routes pursued by each army corps until our arrival in front of Savannah. During this march the Augusta railroad was destroyed, as described above, to include the Oconee bridge. The Georgia Central was destroyed from Walnut Creek, within 3 miles of Macon, to the city of Savannah. The Charleston and Savannah Railroad from the Savannah River bridge to Savannah, the Savannah and Gulf Railroad from Savannah to the Altamaha, the branch from Millen to Augusta for several miles from Millen, and the branch from Gordon to Eatonton suffered severely.

Ponton bridges were built at the following points: Over the Yellow River, at railroad crossing, 100 feet; over the Ulcofauhachee, at road crossing, 80 feet; over the Ocmulgee, at Planters Factory, 200 feet; over the Little River, at railroad crossing, 250 feet; over the Oconee River, at Balls Ferry, 300 feet; over the Buffalo Creek, on Sandersville Road, 400 feet; over the Buffalo Creek, on upper Sandersville Road, 400 feet; over the Ogeechee River, on Louisville Road, 200 feet; over the Ogeechee River, near Burton Station, 200 feet; over the Ogeechee River, Jones Ferry, 300 feet; over the Buck Head Creek, on Millen Road, 100 feet; over the Little Ogeechee, near Station 4½, 80 feet; over the Ogeechee, at Jenks Ferry, 300 feet; over the Ogeechee, at Daltons Ferry, 250 feet; over the Ogeechee, at Hiltons Bridge, 300 feet; total, 3,460 feet.

On the 10th of December the army arrived in front of Savannah. Reconnaissances were pushed south of the Cannouchee River, and, fortunately, a plan of Fort McAllister was found. Other reconnaissances were made along the entire extent of the enemy's front, which was found located along the southeastern edge of the chain of swamps running from the Savannah River, opposite Kings Island, via the point where the Ogeechee Road crosses Salt Marsh Creek, to the junction between Salt Marsh Creek and the Little Ogeechee, and thence through the Vernon, Rosedew, and Beaulieu batteries to Fort McAllister. This line was intrenched in the usual manner, and the defenses were greatly strengthened by closing the sluice gates at the Savannah River and building dams across Salt Marsh Creek, the effect being to make a body of water in front of their entire line.

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*(To appear in the Atlas.)

On the 11th it was decided to attack Fort McAllister, as that was the only obstacle to our free communication with the fleet in Ossabaw Sound. The enemy had destroyed the bridge over the Ogeechee, on the Darien Road, commonly known as the "Kings Bridge." This was rebuilt by the First Missouri Engineers, under direction of Capt. C. B. Reese, Corps of Engineers, and chief engineer Department and Army of the Tennessee, and on the morning of the 13th the Second Division, Fifteenth Army Corps, crossed over and moved along the south bank of the river, reaching the vicinity of Fort McAllister in the afternoon. As soon as the troops could be properly formed the assault was made, and the fort was carried in handsome style. The same evening the general commanding the military division passed down the river and communicated with the fleet. Fort McAllister stood on the right bank of the Ogeechee River, at the first point of "fast land" met with in ascending that stream, and perfectly commanded the channel. The trace of the fort was irregular, the water front conforming to the shore line and the line of "fast land," while the land front was on a regular bastioned trace. The guns—of which there were twenty-two—were generally mounted in barbette. The fort was provided on its land front with a good ditch, having a row of stout palisades at its bottom, well-built glacis, and a row of excellent abatis, exterior to which was planted a row of 8-inch shells arranged to explode when trodden upon. These shells were arranged in a single row just outside the abatis, and were about 3 feet from center to center. It was impossible to move an assaulting force upon the fort without suffering from the explosion of these shells. The fact that nearly all the guns of the fort were mounted in barbette rendered it much easier to carry it by assault, since our skirmish line advancing at a run readily approached within 200 yards, and by throwing themselves flat on the ground were well concealed by the high grass, and could pick off the rebel gunners at their leisure, readily silencing the fire of the fort, after which our assaulting force was formed in full view of and not more than 500 yards from the parapet.

After the capture of Fort McAllister the obstructions in the river, consisting of a double row of piles and torpedoes, were removed, and steamboats ascended to the Kings Bridge, where was established our depot of supplies. Some of the guns were removed from Fort McAllister and taken there preparatory to placing them in battery along our lines, and six 30-pounder Parrotts were brought down from Hilton Head for the same purpose. We were fast getting ready for another assault, which would this time have been made directly upon their main line, when, on the night of the 20th of December, the enemy, crossing the Savannah River on a bridge of flat-boats, made his escape, having abandoned a large number of guns and other material of war, and blown up his ironclads. In this case, as in that of Atlanta, no attempt was made to make regular siege approaches. Our lines were thrust forward at all points to the edge of the water defenses of the enemy without any necessity for siege approaches, and beyond that it was useless to attempt anything of the kind. We could only get into the rebel lines by open assault, which was deemed quite practicable, particularly near the crossing of the Ogeechee Road over Salt Marsh Creek, and in front of our batteries at Shaws Bridge, over the Ogeechee Canal. I had closely reconnoitered the latter point and found that the natural obstacles were not very great, but the enemy's works were strongest here. Soon after our occupation of the city of Savannah, the major-general commanding directed me to select a new line, to be intrenched for the defense of such stores, depots, and material as we would leave there in future operations. In company with Captain Reese, I made a careful reconnaissance, and decided upon the location and character of the works. These were, in their main features, a system of large lunettes to be closed at the gorge and to be placed in defensive relations with each other, so that they might be held independently, but to be also connected by curtains of infantry parapet, so as to be used as a continuous line, if that was deemed desirable. The estimated garrison was 5,000 men. The location of the new lines was very nearly the same as those of 1814.

Before leaving Savannah on the campaign through the Carolinas, by request of General Grover, who was left in command at Savannah, I handed him a paper, of which the following is a copy:

Headquarters Military Division of the Mississippi,
Chief Engineer's Office,
Savannah, Ga., *January 21, 1865.*

Major-General Grover,
Commanding U. S. Forces, Savannah:

General: In accordance with your request I have the honor of submitting the following memoranda, with reference to the defense of the city of Savannah:

First. The defense of the city itself: This is accomplished by the line of works now in process of construction, after the plan indicated in my letter to Major-General Sherman, dated December 26, 1864. These works are now ready to receive sixty guns, partly siege and partly field artillery, and in my opinion are in a condition which would warrant their defense by the garrison estimated for. Captain Suter, U. S. Engineers, and chief engineer Department of the South, has been furnished with a trace of this line, on which the several positions of the guns composing the complete armament are indicated. Captain Suter has also been furnished with those maps captured at this city which relate to the defense. Opposite the city, on the main Carolina shore, two small works should be built to command the Union Causeway and the Huger Causeway. The above contemplates an attack by a much larger force than the garrison, and in my opinion, will never be made.

Second. The defense of the approaches: Three main roads lead into the city from inland, viz, the Ogeechee plank road (Darien Road), the Louisville stage road, the Augusta stage road. The last two join within one mile and a half of the city. The points where the enemy's late lines crossed these roads furnish the best defense. When taken in conjunction with the obstacles formed by opening the sluice gates at high tide, the positions are strong. If the bridge across the Ogeechee at Kings is destroyed, it effectually cuts off direct approach by that road, and it can only be reached by crossing the river above and getting to it by some of the numerous cross-roads. An enemy would not be likely to do this, unless he were in largely superior force, since he would necessarily put himself in a "pocket."

Third. The defense of the river navigation: This is best accomplished by a force stationed at this city large enough to go out and fight any enemy that would be likely to approach In order that our opponents might reach any of the points where they could injure us much, they would be compelled to thrust themselves some miles beyond us, leaving whatever garrison there might be in Savannah on their flank and in rear. They could not interrupt navigation without establishing themselves in inclosed works upon the bank of Saint Augustine Creek (we hold Fort Jackson), and a very short time would suffice for the capture of any enemy having temerity enough to do this. With all our resources of water transportation I regard it impossible for our enemy to make a successful lodgment on Saint Augustine Creek.

I am, General, very respectfully, your obedient servant,

O. M. Poe,
Captain, Engineers, Brevet Colonel, U. S. Army,
Chief Engineer Military Division of
the Mississippi.

A map* is in course of preparation, under my direction, which will clearly show the topography of Savannah and vicinity, the works of attack and defense, the new lines constructed during our occupation of the city, and the lines of 1814. As soon as completed it will be forwarded to the Engineer Department.

Third. The Campaign from Savannah, Ga., to Goldsborough, N. C., from January 25, 1865, to March 22, 1865.

For this campaign, inaugurated in midwinter, to be made through a country famous for the extent of its swamps, all of which for 500 miles distance were to be crossed at right angles, at that season of the year when they were flooded wtih water and generally regarded as impassable for troops, the engineer department was organized with great care. The ponton trains, of which descriptions have already been given, were put in perfect order. Every officer and man belonging to the engineer organization was duly impressed with the importance of the part we were to take in the march, where so much was to depend upon prompt and efficient bridge-building and road-making. The same organization of the department was preserved as that made for the Savannah campaign. To save the trouble of looking for it in the preceding pages it is repeated.

First. Staff: O. M. Poe, Captain Engineers, Brevet Colonel, U. S. Army, chief engineer Military Division of the Mississippi; C. B. Reese, captain Engineers, brevet colonel, U. S. Army, chief engineer Department and Army of the Tennessee (Right Wing); Amos Stickney, first lieutenant Engineers, brevet captain, U. S. Army, assistant to Captain Reese; William Ludlow, first lieutenant Engineers, brevet major, U. S. Army, chief engineer Army of Georgia (Left Wing); William Kossak, captain, aide-de-camp, chief engineer Seventeenth Army Corps; Klostermann, captain, etc., chief engineer Fifteenth Army Corps.

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*(See Map 2, Plate LXX, of the Atlas.)

Second. Engineer troops and troops of the line on engineer duty: First Michigan Engineers and Mechanics, Col. J. B. Yates, unassigned; First Missouri Engineers, Lieut. Col. William Tweeddale, Right Wing; Fifty-eighth Indiana Volunteer Infantry, Lieut. Col. J. Moore, Left Wing.

Third. Pontoniers and ponton trains: Right Wing, First Missouri Engineers; Left Wing, Fifty-eighth Volunteer Infantry.

The ponton trains remained exactly as before specified. The tool trains remained the same, but the number of tools carried along by brigade wagons was greatly increased, particularly the number of axes.

When the movement actually commenced a portion of the army marched via Sisters Ferry. The ponton train of the Left Wing accompanied this column. All other engineer troops and trains were transported by water to Beaufort and moved thence by land. Owing to the season and the nature of the country through which we marched the demand for labor of engineer troops was constant. The heavy rains which fell just as the movement commenced greatly impeded the march of the column, which crossed the Savannah at Sisters Ferry. To enable it to progress at all 700 feet of ponton bridge were built and 1,000 feet of trestle bridge, also some miles of corduroying. The Right Wing met with similar obstacles, though not so serious. A ponton bridge was thrown across Whale Branch, and fully one-quarter of the road thence to Pocotaligo was corduroyed. On the 1st of February the movement from Sisters Ferry and Pocotaligo commenced, the enemy at that time endeavoring to hold the line of the Salkehatchie. The Left Wing moved toward Duck Branch Post-Office, and the Right Wing by the two roads between Salkehatchie and the Coosawhatchie, the Seventeenth Corps being directed on Rivers Bridge and the Fifteenth Corps on Duck Branch Cross-Roads, with a division thrown out to Angleys Post Office. On the night of the 3d of February the enemy's position at Rivers Bridge was carried by a portion of the Seventeenth Army Corps. On the 4th the Fifteenth Army Corps reached Bufords (or Beauforts) Bridge and found it destroyed, the enemy having evacuated his works at this point. Twenty-two bridges, scattered over a mile of swamp, and averaging about 25 feet in length, were rebuilt during the night and the whole road through the swamp was corduroyed. The Left Wing, with the cavalry on its left flank, continued its march direct on Barnwell. On February 7 the Charleston and Augusta Railroad was reached at Midway by the Seventeenth Army Corps, at Bamberg by the Fifteenth Army Corps, at Grahams by the Twentieth Corps, and at Blackville by the Fourteenth Corps, with the cavalry on its left. The ponton train of the Right Wing was pushed forward toward, and all the infantry of the entire army, together with the Michigan Engineers, were put at work destroying the railroad. This was effectually done, all wood-work was burnt, every rail was twisted, and all water tanks, engines, and machinery of all kinds destroyed to include the Edisto Bridge and Williston, and partially destroyed between Williston and Johnsons.

During the night of the 9th a ponton bridge was thrown at Binnakers, and the enemy driven away from the position he had taken to dispute the crossing. Another ponton bridge was thrown at Holmans, and all our force was across by the evening of the 11th, the Left Wing crossing at Duncans and Guignards Bridges. The Right Wing moved direct upon Orangeburg. The enemy opposed the crossing of the North Fork of the Edisto River, but, as usual, he was driven away and three ponton bridges built, one on the main Orangeburg road, and the other two at Shillings Bridge. The Seventeenth Corps occupied Orangeburg and destroyed the railroad thence to and including the Congaree River bridge. The Left Wing, meanwhile, was moving toward Columbia by the nearest roads. The Right Wing now directed its march toward Columbia, and after some opposition at Thomas Creek and Congaree Creek, where the enemy was found well intrenched, arrived at a point opposite the city on the 16th of February. The bridges over the Saluda, Broad, and Congaree were all found to have been burned. A ponton bridge was built at the Saluda River bridge, near the factory, and a portion of the Fifteenth Corps crossed during the night. The Left Wing ponton bridge was built over the Saluda at Zion Church, 9½ miles above Columbia, and some force crossed. On the 17th a ponton bridge was built just above the ruins of the former bridge over Broad River, 3 miles above Columbia, and the Right Wing crossed to the north bank and occupied the city, the greater part of which was burned during the night. Many reasons are given for this flagrant violation of General Sherman's orders, but, as far as I could judge, it was principally due to the fact that the citizens gave liquor to the troops until they were crazily drunk and beyond the control of their officers. The burning cotton, fired by retreating rebels, and the presence of a large number of escaped prisoners, excited the intoxicated soldiers to the first acts of violence, after which they could not be restrained. I do not know that I am called upon to give an opinion respecting this matter, but I volunteer the above. One thing is certain, the burning houses, lighting up the faces of shrieking women, terrified children, and frantic, raving, drunken men, formed a scene which no man of the slightest sensibility wants to witness a second time.

On the 18th the Left Wing crossed the Broad River on a ponton bridge thrown at the mouth of Wateree Creek, near Freshleys Mills, and commenced the destruction of the Greenville and Columbia Railroad from Alston toward Columbia. On the 19th, by direction of General Sherman, I destroyed all the railroad shops, depots, city gas-works, etc., in Columbia, the Michigan Engineers furnishing the working parties. On the 20th the march was resumed. The Seventeenth Army Corps, together with the Michigan Engineers, at work destroying the Columbia and Charlotte Railroad from Columbia northward, while the Fifteenth Corps was at work from Columbia toward Kingsville. The Charlotte railroad was thoroughly destroyed from Columbia to White Oak Station, 44 miles. At Winnsborough the whole army was concentrated, and the Left Wing assisted in the destruction of the railroad thence to the northward. From Winnsborough and White Oak the Left Wing and the cavalry moved to Rocky Mount, and the Right Wing to Peays Ferry. A ponton bridge was thrown over the Catawba (Wateree) at each of these points, and after a great deal of trouble arising from high water, rapid currents, and muddy roads, the army was transferred to the eastern bank of the river. This crossing was begun on the morning of the 23d of February, and was completed on the 27th, after one bridge at Rocky Mount had been carried away. It was 700 feet in length, and about 200 feet of it was totally lost. The balance was recovered and the bridge rebuilt. By this time the cavalry had passed through Lancaster, the Twentieth Corps was at Hanging Rock, and the Right Wing was at Tillersville, in the vicinity of which it crossed Lynchs Creek, after almost incredible labor in building bridges and corduroyng roads. The remainder of the army crossed at Fenillys and McManus bridges. The whole army was now moving on Cheraw, and was concentrated there on the 3d of March without any opposition not easily overcome. A large amount of material of war was captured at Cheraw, all of which, except three guns brought away as trophies, was destroyed by the Michigan Engineers. The march was resumed on the 6th of March, the Fifteenth, Seventeenth, and Twentieth Corps crossing the Pedee on a ponton bridge at Cheraw, and the Fourteenth Corps and cavalry on another at Sneedsborough. The whole army now aimed to concentrate at Fayetteville, N. C., the cavalry passing through Rockingham and thence via the first road north of the Fayetteville and Albemarle plank road; the Fourteenth Corps via Loves Bridge over Lumber River; the Twentieth Corps via McFarlands Bridge; the Fifteenth Corps via Gilchrists Bridge, and the Seventeenth Corps via Campbells Bridge. All these bridges had been destroyed by the enemy and each was replaced either by a ponton or a trestle bridge. The concentration at Fayetteville was effected on the 11th of March with very little opposition, though the enemy's cavalry was all around us. At Fayetteville it was found that the enemy had greatly enlarged the capacity of the old U. S. Arsenal. The major-general assigned to me the special duty of destroying it. The Michigan Engineers were at once set at work to batter down all masonry walls, and to break to pieces all machinery of whatever kind, and to prepare the two large magazines for explosion. The immense machine shops, foundries, timber sheds, etc., were soon reduced to a heap of rubbish, and at a concerted signal fire was applied to these heaps, and to all wooden buildings and piles of lumber; also to the powder trains leading to the magazines. A couple of hours sufficed to reduce to ashes everything that would burn, and the high wind prevailing at the time scattered these ashes, so that only a few piles of broken bricks remained of that repossessed arsenal. Much of the machinery here destroyed had been brought at the beginning of the war from the old arsenal at Harpers Ferry.

On the 13th ponton bridges were thrown over the Cape Fear River as follows: That of the Left Wing just below the ruins of the road bridge (it having been burned by the enemy), and that of the Right Wing about 3 miles below, and the army commenced crossing. On the 15th the bridges were taken up and the Left Wing, together with the cavalry, moved out on the Raleigh Road. The supply trains of the cavalry and of the Left Wing, under escort of one division from the Fourteenth Corps and one from the Twentieth, after going some 7 or 8 miles, turned to the eastward, taking the main Goldsborough Road, whither they were ordered. The cavalry and the other four divisions continued on the Raleigh Road until the enemy was encountered at Taylors Hole Creek. Early next morning the enemy, consisting of Rhett's brigade of South Carolina Heavy Artillery, was attacked and quickly dislodged from his intrenchments. Our troops pressed on in pursuit and soon encountered the enemy in considerable force intrenched at the cross-roads south of Averasborough, his lines extending from Cape Fear River to Black River. At this point the peninsula between the two rivers is narrowest. By the time proper dispositions were made to attack it was dark, and before daylight next morning, March 17, the enemy was gone, but was closely followed as far as Averasborough by one division of the Twentieth Corps. A map* illustrating the operations at this point was forwarded to the Bureau of Engineers with my letter dated August 14, 1865.

The pursuit to Averasborough developed the fact that the enemy had retreated in the direction of Smithfield, and our march was resumed along the main road hence to Goldsborough. On the morning of the 19th the Right Wing was within 2 miles of the Left. The enemy having kept a safe distance from us, and destroyed all bridges leading to the northward in advance of the head of our column, it was inferred that he did not intend to offer any serious opposition to our march. The Right Wing was ordered to move from Lee's Store direct to Goldsborough, and the Left Wing aimed to reach the same point via Coxs Bridge. When near Bentonville the enemy moving down the Smithfield Road suddenly attacked the Left Wing and gained a temporary advantage over its leading division, but the other three divisions, the cavalry, and the Michigan Engineers, getting into position, repulsed every subsequent attack of the enemy, all of which were of a very desperate character, as the rebel commander well knew that daylight of next morning would bring with it the entire Right Wing; and such was the case—that part of the army marching nearly all night and advancing via the same road that the Left Wing was on, but from the opposite direction, reached the enemy's rear, not having been stopped a moment by the opposition of the enemy. The rebel line was, of course, at once doubled back and a junction was made between the Right and Left Wing of our forces. The next day

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*(See Plate CXXXIII, Map 1 of the Atlas.)

(March 20) the First Division, Seventeenth Army Corps, succeeded in getting within 200 yards of the bridge over Mill Creek, on the Smithfield Road, and the Fifteenth Corps carried and held the entire line of the enemy's skirmish pits in its front. Again the enemy ran away during the night. We pursued him 2 miles beyond Mill Creek. On the 14th of August I transmitted to the Engineer Bureau a map* which was intended to illustrate this battle.

The trains meanwhile had never stopped their movement toward Goldsborough, and the troops now following soon begun to pour into that town, already occupied by the troops of General Schofield, and the most wonderful campaign of the war was ended. Two ponton bridges were built over the Neuse at Coxs, and two more near the county bridge, upon which everything crossed.

Supplies of all kinds were very badly needed, and, amongst the rest the canvas covers of the ponton boats needed renewal. In the train attached to the Right Wing this was particularly the case, since many of the covers had been in the water an aggregate of sixty days. Attention is especially directed to this train, because the material had been hauled from Nashville to Goldsborough upon wagons and had been in constant use, and yet the train was serviceable. Indeed, all that was required to make it perfectly efficient was a new set of canvas covers.

Fully one-eighth of the whole army was without shoes, and nearly as badly off for the other articles of clothing, having now marched through the heart of the enemy's country, over swamps and through forests, nearly if not quite 500 miles, occupying sixty days of time, during which they drew but little more than their sugar and coffee from the Government, gathering subsistence for themselves and animals from the enemy's country. During our march from Atlanta to Savannah our line of march was parallel to the larger water-courses. On this it led at right angles to them all, and, as we expected, the difficulties encountered by us were greatly increased. Our line of march was chosen near the junction between the clay of the uplands with the sand of the lower country, which may be tolerably well defined by tracing a line through the lower rapids on each of the streams we crossed. It was hoped and expected that along this line we would find the best roads and the minimum amount of mud and swamp, while at the same time it passed through or in the vicinity of the towns it was considered important to strike. Our supposition was entirely correct, as proven whenever we deflected much from this line, as at the crossing of the Catawba. There are but few of us who will not remember the labor, hardship, and exposure of the 23d, 24th, 25th, and 26th of February. Still our route, at its best, involved an immense amount of bridging of every kind known in active campaigning, besides some 400 miles of corduroying. The latter was a very simple affair where there were plenty of fence rails, but in their absence involved the severest labor. We found that two good fences furnished enough rails to corduroy a strip of road as long as one of them so as to make it passable. I estimate the amount of corduroying on this campaign at fully 100 miles to each army corps, making an aggregate of 400 miles. This is a moderate estimate. This kind of work was rarely done by the cavalry, since their trains moved with the infantry columns. The Right Wing built fifteen ponton bridges, having an aggregate length of 3,720 feet. The Left Wing built about 4,000 feet, thus making a total of 7,720 feet, or nearly 1½ miles. The amount of trestle bridge built was not measured, but it was not so great. In corduroying, the entire available force of the army was used—engineers, pioneers, and infantry. The pontoning was all done by engineer troops, according to the organization already given, and the building of trestle bridges by engineers and pioneers. Surveys have been made of the entire line of march of each army corps, as well as the route pursued by the headquarters military division. The latter was as good a survey as could be made with odometer and prismatic compass, and was under charge of Capt. H. A. Ulffers, assistant adjutant-general volunteers, on engineer duty. In addition to the officers already named as on engineer duty, the following, belonging to the Coast Survey, were courteously placed under my orders by Mr. J. E. Hilgard, in charge of that work, viz: Messrs. Cleveland Rockwell, F. W. Dorr, W. Harding, and F. Platt. Owing to the rapidity of the march there was but little opportunity for the finer class of surveying which these gentlemen were capable of doing. They made plane table surveys of Pocotaligo and Goldsborough, and were always ready to avail themselves of any chance that offered itself to make themselves useful. My thanks are due and freely tendered them. A map* upon a scale of 1 :350000, illustrating the march from Savannah to Goldsborough, is finished and a copy is now being made. The original will be transmitted to the Engineer Bureau as soon as this is done.

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*(See Plate CXXXIII, Map 2 of the Atlas.)

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*(Embodied in Plate CXVII of the Atlas. The original is on file in the office of the Chief of Engineers, U. S. Army.)

In closing this section of this report, I desire to bear testimony to the good conduct and efficiency of the individuals composing the engineer organization, and above all my thanks are due to Colonel Reese. It is impossible in a paper like this to give an adequate idea of the value of his services. The hearty support he gave me in all these long campaigns will never be forgotten, and it affords me great pleasure to know of its recognition by the Government in the grade of brigadier-general by brevet.

Fourth. The campaign from Goldsborough, N. C., to Raleigh, N. C., and the march from Raleigh to Washington City, from April 10, 1865, to 20th of May, 1865.

Upon our arrival at Goldsborough our attention was devoted to refitting the army for a new campaign. The grand army was reorganized so that it consisted of three divisions of two army corps each, viz: The Army of the Tennessee, of the Fifteenth and Seventeenth Corps, being the Right Wing; the Army of the Ohio, Department of North Carolina, of the Tenth and Twenty-third Corps, being the Center, and the Army of Georgia, of the Fourteenth and Twentieth Corps, being the Left Wing. The engineer organization to correspond with this was:

First. Staff: O. M. Poe, captain Engineers, brevet colonel, U. S. Army, chief engineer Military Division of the Mississippi; C. B. Reese, captain Engineers, brevet colonel, U. S. Army, chief engineer Department and Army of the Tennessee; W. J. Twining, captain engineers, brevet lieutenant-colonel, U. S. Army, chief engineer Department of North Carolina; W. Ludlow, first lieutenant Engineers, brevet major, U. S. Army, assistant to chief engineer Military Division of the Mississippi; A. Stickney, first lieutenant Engineers, brevet captain, U. S. Army, assistant to Colonel Reese; A. N. Damrell, first lieutenant Engineers, U. S. Army, assistant to Lieutenant-Colonel Twining.

Second. Engineer troops and troops of the line on engineer duty: First Regiment Michigan Engineers and Mechanics, Col. J. B. Yates commanding, unassigned (under direct orders of chief engineer); First Regiment Missouri Engineers, Lieut. Col. William Tweeddale, Right Wing Pontoniers; detachment Fifteenth Regiment New York Volunteer Engineers, ——— commanding, Center Pontoniers; Engineer Battalion, Twenty-third Army Corps, Center Engineers; Fifty-eighth Regiment Indiana Volunteer Infantry, Lieut. Col. J. Moore commanding, Left Wing Pontoniers.

Third. Ponton trains:

	Feet of canvas.
With Right Wing	600
With Center Wing	600
With Left Wing	800
Total	2,000

The organization of pioneers and tool trains was exactly as described heretofore, except that it was extended to the additional force that had joined us.

I mention the organization of the engineer department because I found that with all the experience gained in the remarkable campaigns of Savannah and the Carolinas nothing better was suggested. It was found to be efficient, and it was so simple as to be readily handled. On the 10th of April the army moved forward upon the road to Raleigh, meeting with feeble resistance. The usual corduroying and bridge building commenced at once, and four ponton bridges were laid across the Neuse on the 11th. The city of Raleigh was entered without opposition on the 13th, and in a day or two afterward followed the convention between General Sherman and the rebel general, Joseph E. Johnston. At the time of this convention we had pushed a ponton train out to Avens Ford, on Cape Fear River, and had built a bridge there.

After the surrender of the rebel forces the forces composing the Right and Left Wings, as already described, commenced their march to Washington. The map, on a scale of 1:350000, prepared under my direction, shows the routes of march from Goldsborough to Raleigh, and thence to Washington, D. C.; also the points at which ponton bridges were built. Of course, there was no especial merit in anything done by the engineers during this march any more than there would be during any other march in a time of profound peace.

Upon our arrival at Washington the ponton trains, which had done us such efficient service, were turned over to an officer designated by the Engineer Bureau. One of them had been hauled on wagons from Nashville, Tenn., via Chattanooga, Atlanta, Savannah, and Raleigh to this city, and the other had in like manner been hauled over the same route from Chattanooga, and they had been in almost daily use for a year with one single renewal of the canvas covers, and were in excellent condition when delivered here. Can any facts go further to show the value of the canvas train in campaigns of the character described? No wooden boats would have stood a moiety of the rough usage bestowed upon these. A few days hauling over the mountains of Georgia, or the corduroy roads of the Carolina swamps, would have used them up.

As the result of experience, I would suggest that a change be made in the wagons of the canvas ponton train so that the wheels and axles shall conform to those in use in the quartermaster's department, and the balance of the woodwork be that proposed by Colonel Pettes. The reasons for this recommendation are given at some length in a former communication to the Bureau. I may mention that the bridge equipage in charge of the Fifty-eighth Indiana Volunteers was hauled all the way from Chattanooga to Washington on the ordinary quartermaster's wagon, the convenience of which was constantly observed for 1,300 miles.

Great attention should be paid, in organizing for future campaigns, to the matter of tool trains. Operating as we did in a sandy country, we found but little use for the pick and spade, but the ax and the short-handled shovel were in constant demand.

Every army corps ought to be provided with one good engineer regiment, which ought to be capable of doing anything required at its hands. As examples of such regiments I will refer to the two which accompanied us. I never called for workmen to work in wood, metal, or stone, but good mechanics were at once forthcoming. Although the Fifty-eighth Indiana Infantry was not enlisted as an engineer regiment, yet under the tuition of their efficient colonel—afterward Bvt. Brig. Gen. George P. Buell—they became very valuable; indeed, for all purposes required at their hands, were as much so as the engineer regiments were, but the duties they were called upon to perform were not so varied. The constant practice of our troops has made them tolerably good judges of what constitutes a good defensive line, and lightened the labors of the engineer staff very materially. I was frequently surprised by the admirable location of rifle trenches and the ingenious means adopted to put themselves under cover. The accuracy of the fire of sharpshooters on both sides led the troops to adopt the "Head-log" in all their rifle trenches. This is a good, stout log, of hard wood if possible, which is cut as long as possible and laid upon blocks placed on the superior slope a foot or two outside the interior crest. The blocks supporting the "head-log" raise it sufficiently from the parapet to allow the musket to pass through underneath it and steady aim to be taken, while the log covers the head from the enemy's fire. Frequently the blocks are replaced by skids, which rest on the ground in rear of the trench, so that if the "head-log" is knocked off the parapet by artillery fire it rolls along these skids to the rear without injuring anybody. I examined many miles of these "head-logs" without finding any indication that their use had been otherwise than advantageous. I saw no evidence that a single man had been killed on either side by splinters thrown from them by artillery projectiles, or from logs thrown off the parapet by the same means.

Recapitulation of work done by engineer troops, and troops under engineer direction, during the campaign covered by this report.

What campaign.	Ponton bridge built.	Trestle bridge built.	Road corduroyed (estimated).	Road destroyed (estimated).	Road surveyed and mapped.
	Feet	*Feet*	*Miles*	*Miles*	*Miles*
Atlanta campaign	3,500	3,330	100	26	980
Savannah campaign	3,460	1,700	60	240	1,700
Goldsborough campaign	7,720	4,000	400	120	2,500
March to Washington	*3,000	------	20	------	1,600
Total	17,680	9,030	------	------	------
Total miles	3.35	1.7	530	386	6,780

All of which is respectfully submitted.

O. M. Poe,
Captain, U. S. Engineers, Brevet Brigadier-General, U. S. Army.

Reports of Maj. James M. Hubbard, Twelfth Missouri Cavalry, Commanding Pontoniers.

Pontoniers in Raid of Wilson's Cavalry into Northern Alabama, 1865.

Headquarters Ponton Train, Cavalry Corps,
Military Division of the Mississippi,
Near Macon, Ga, *April 25, 1865.*

Major: I have the honor to report that the ponton train—consisting of fifty-eight wagons loaded with thirty canvas ponton boats and the necessary lumber for laying a bridge of thirty boats, also the battalion of pontoniers (6 commissioned officers and 205 effective men, including 58 teamsters, 2 harness makers, and 4 blacksmiths)—left Eastport, Miss., at 8 a. m. March 20, 1865, and proceeded to Bear River via Iuka. Laid ponton bridge across the same 6 miles from Iuka the same day. On the 22d of March the ponton train was attached to Second Division, Cavalry Corps, and was guarded by troops from that division. We moved in rear of the Second Division train, which obliged us to corduroy many of the bad places in the roads, for our mules were small and not in very good condition. Loads so heavy that on March 28 I had to abandon about one-fourth of all the lumber of the kind that could be procured in the country. Crossed Big Black Warrior on 30th of March and marched to and bridged Little Black Warrior on the 31st of March. On the 3d of April laid a bridge across Catawba River. All trains belonging to the command crossed and marched 20 miles same day. Arrived at Selma, Ala., April 6, having marched the distance of about 300 miles in eighteen days, and laid three ponton bridges. The roads were almost impassable, having in many instances to use the whole battalion in lifting wagons out of the mud. Laid a bridge across the Alabama River in thirty hours. With the addition of the thirty canvas boats, six wooden pontons and three large barges were used, but owing to the rise of water and driftwood it was broken twice in the center. By much assistance it was made substantial. Commenced taking up the bridge at 10 a. m. 10th of April, reserving only twelve boats and appurtenances. Destroyed and abandoned thirty wagons, eighteen boats, and mounting the battalion of pontoniers on the surplus mules arrived at Montgomery, Ala., on 13th of April, having laid one bridge across Cypress Creek and traveled the distance of 65 miles over a swampy road in three days and a half. Moved on the Columbus Road on 14th * * * We arrived at Columbus, Ga., April 17, having traveled about 100 miles in five days. Left Columbus at 2 a. m. 18th and moved toward Macon, Ga.; traveled 41 miles. Arrived in camp near Macon, Ga., at 12 m. 21st April, making about 100 miles in three days and a half, with teams in good condition.

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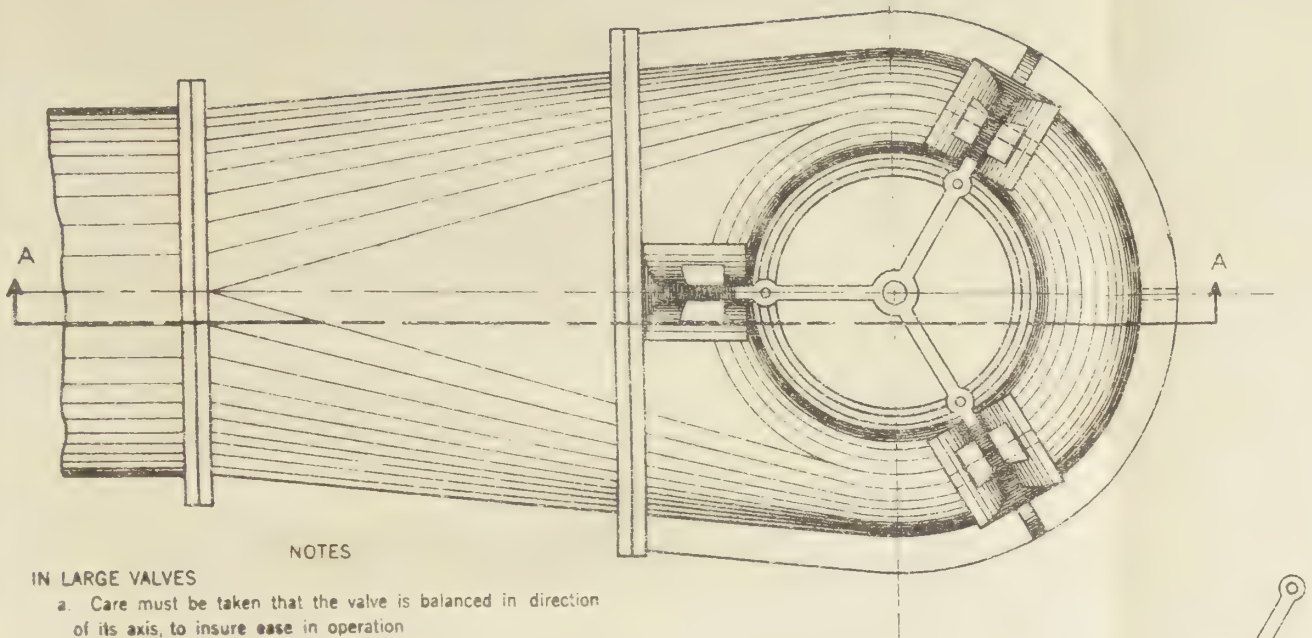
* Estimated.

Hoping the above may prove satisfactory, I am, Major, very respectfully, your obedient servant,

J. M. Hubbard,
Major, Comdg. Detach. Twelfth Missouri Cav.,
Batt. of Pontoniers.

Maj. E. B. Beaumont,
Asst. Adj. Gen. Cavalry Corps,
Mil. Div. of the Mississippi.



TOP VIEW
Crosshead removed

NOTES

IN LARGE VALVES

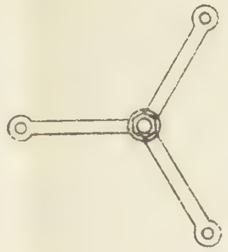
a. Care must be taken that the valve is balanced in direction of its axis, to insure ease in operation

b. Valve seats may better be separately constructed rings, carefully machined to fit, and attached to valve castings. They may be of other material than the exit conduits.

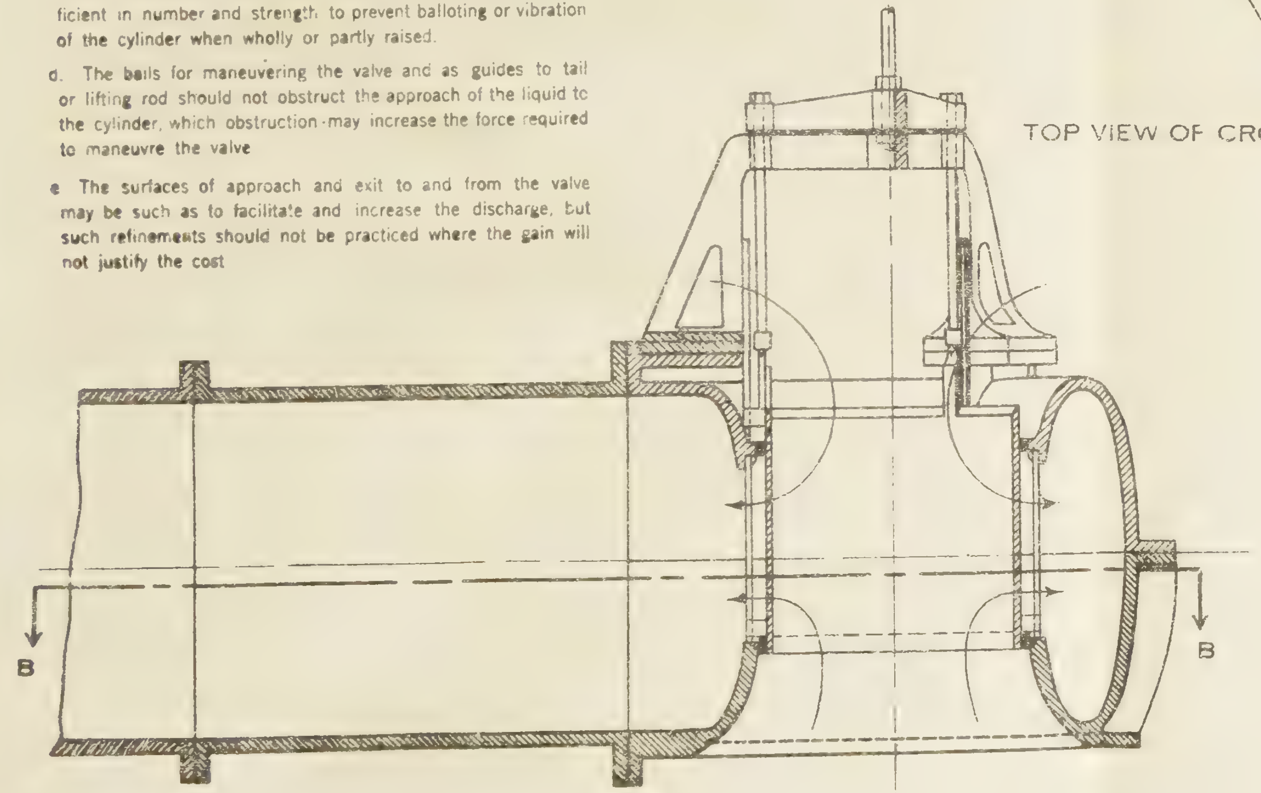
c. The guides, slide bars, etc., should accurately fit and be sufficient in number and strength to prevent balloting or vibration of the cylinder when wholly or partly raised.

d. The bails for maneuvering the valve and as guides to tail or lifting rod should not obstruct the approach of the liquid to the cylinder, which obstruction may increase the force required to maneuvre the valve

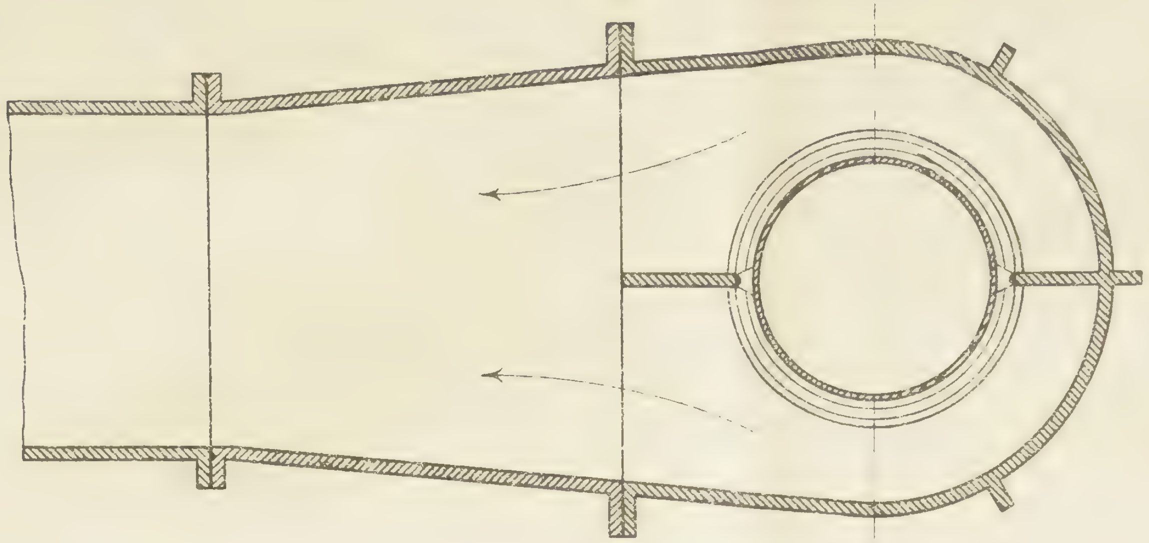
e. The surfaces of approach and exit to and from the valve may be such as to facilitate and increase the discharge, but such refinements should not be practiced where the gain will not justify the cost



TOP VIEW OF CROSSHEAD



SECTION A-A
Valve closed



SECTION B-B

EXPLANATION

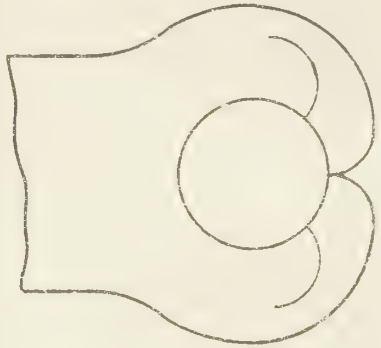
THE MOVING PART IS A SECTION OF A RIGHT CYLINDER OPEN AT BOTH ENDS AND ACTUATED POSITIVELY BY HAND OR OTHERWISE.

WHEN VALVE IS LIFTED THROUGH A DISTANCE EQUAL TO OR GREATER THAN THE RADIUS OF THE INTERIOR OF THE CYLINDER, (IF SUBMERGED) THE LIQUID IN WHICH IT IS IMMERSED MAY DISCHARGE: 1. THROUGH THE UNOBSTRUCTED INTERIOR OF THE CYLINDER. 2. THROUGH THE ORIFICE AT ITS BASE GIVING THUS A DISCHARGE EQUAL TO THAT OBTAINED THROUGH TWO CYLINDRICAL VALVES OF SAME SIZE OF ORIFICE.

IF r BE RADIUS OF INTERIOR OF VALVE AND OF VALVE SEAT
$\mathcal{R}$ BE RADIUS OF DISCHARGE PIPE
THEN $2\pi r^2 = \pi \mathcal{R}^2$
OR $\mathcal{R} = r\sqrt{2} = 1.414\,r$
FOR INSTANCE IF THE MOVING CYLINDER BE 5 FEET IN DIAMETER. THE DISCHARGE PIPE MUST BE AT LEAST 7.07 FEET IN DIAMETER

THE DRAWING SHOWS ESSENTIAL PARTS ONLY, BUT IS READILY UNDERSTOOD. THE VALVE MAY BE MADE OF MANY FORMS AND OF VARIOUS MATERIALS. INASMUCH AS THE PRESSURES IN THE VALVE PRODUCE STRESSES OF TENSION ONLY, THE BARREL OR CYLINDER MAY BE OF ORDINARY THICKNESS OF BOILER PLATE. WITH FLANGES IF NECESSARY FOR VALVE SEATS. IF ITS WEIGHT BE COUNTERPOISED THE VALVE MAY BE VERY EASILY MOVED BY ANY POSITIVE ACTING FORCE.

GEN. WILLIAM L. MARSHALL
CONSULTING ENGINEER TO
SECRETARY OF THE INTERIOR



To increase efficiency of valve and prevent possible violent shocks under high heads deflecting vanes may be constructed in valve casings as illustrated in this sketch.

DEPARTMENT OF THE INTERIOR
UNITED STATES RECLAMATION SERVICE

BALANCED VALVE

FOR HIGH OR LOW HEADS GIVING MAXIMUM DISCHARGE
WITH MINIMUM MATERIAL AND WITH LEAST MOVEMENT
POSSIBLE IN PROPORTION TO DISCHARGE

PROPOSED BY
GEN. WILLIAM L. MARSHALL
CONSULTING ENGINEER
TO SECRETARY OF THE INTERIOR
1913

ACCESSION NO. 15127

Cylindrical Valves, and Automatic Crests of Dams

BY

Gen. W. L. MARSHALL

The valves or water gates used or projected to be used by the Reclamation Service under great heads at reservoir outlets are slide gates for guard valves and automatic plug, or needle, valves for closely regulating discharges. Under great heads the slide valves are difficult to operate, and when of considerable size are not practicable under pressures due such heads, especially since roller bearings applied to them have failed in practice. The use of slide valves must then be restricted to sluice gates operated under moderate or low heads, and to guard gates for regulating valves, to be operated in still water.

The regulating valves, designed and used in the Reclamation Service, form a distinct cylindrical class wherein the cylinder is closed at top, which top projects beyond the cylindrical body and forms a hydraulic piston in direct connection with the valve. The bottom of such type is also closed by a conoidal or concave surface of revolution terminating in a point at the axis of the cylindrical body prolonged. The projection of the top surface or ''bull-ring'' closely fits the surface of, and moves smoothly into and out from a hood or housing just as a piston of a hydraulic engine moves in its cylinder; and carries the plug or valve to and from its seat.

These automatic but controllable plug or needle valves are in many of their principal features, if not all of them, the inventions of Mr. O. H. Ensign, Chief Electrical Engineer, and of Mr. F. Teichman, Engineer in the Reclamation Service, and are very interesting, useful, and scientific applications of the laws of the mechanics of fluids, correct in principle and extremely ingenious. Quite a number of the Ensign valves have been in use for several years. The Teichman type has not yet been tried, but has been contracted for to be placed in the Elephant Butte Dam on the Rio Grande.

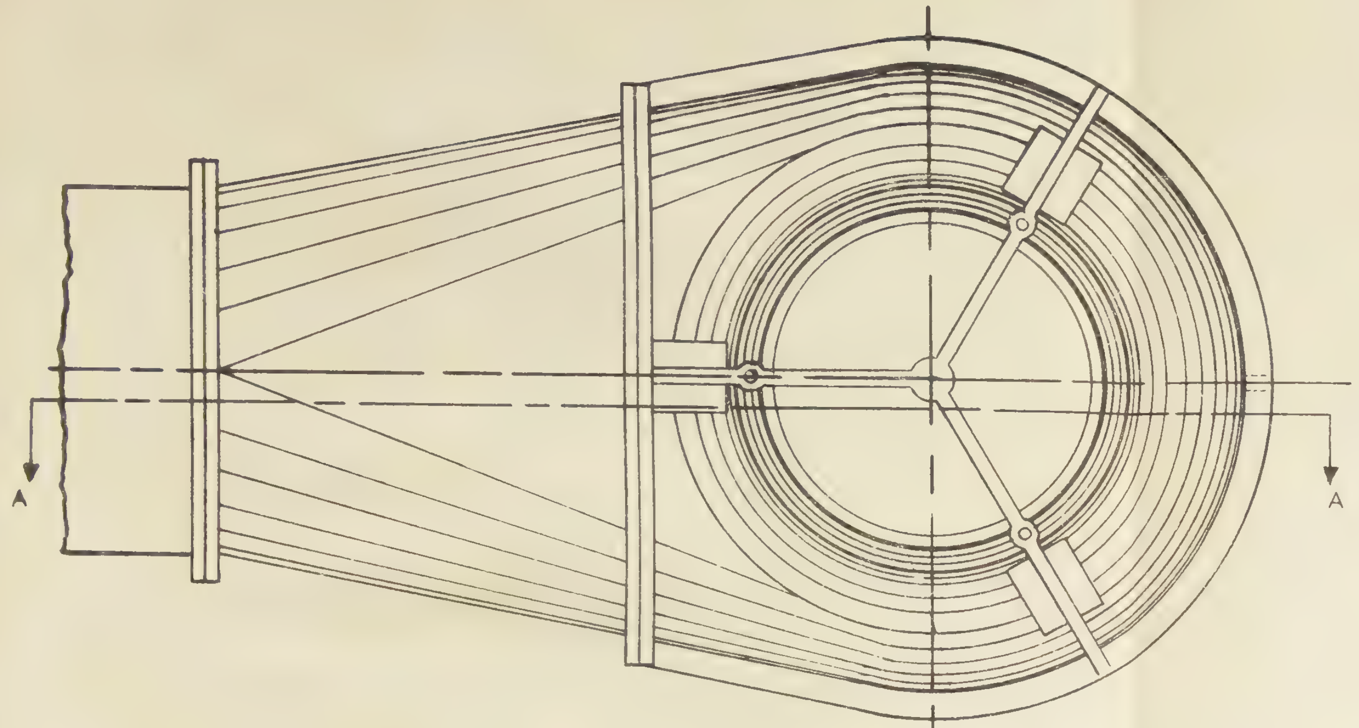
The regulating plug valves are automatic but controllable, and are used under heads up to and greater than 100 feet quite successfully.

They still have some minor defects, but all such defects seem to be remediable and doubtless will be remedied shortly.

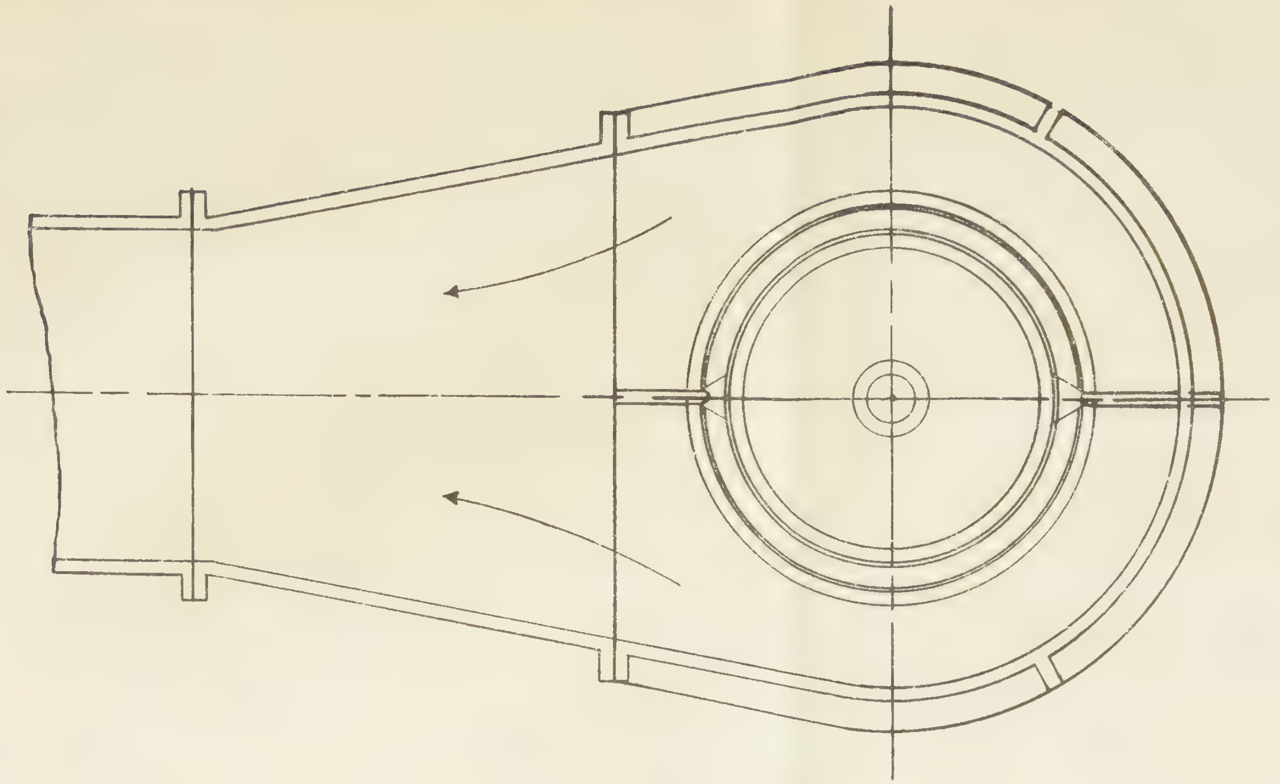
In operating these valves not only is hydrostatic pressure used and controlled, but auxiliary forces such as ''suction'' from artificially produced partial vacuums in the housing, and ''reaction'' due the change in direction of the discharge by the curved surface of the bottom of the plug. The main differences between the Ensign and Teichman types consist in the relative intensity of these forces employed and relative importance of or reliance placed in the three forces named, and in methods of control and operation. Each type has distinctive good points.

Notwithstanding such defects as have been met in plug valves (up to 10 feet diameter), they are believed to be the best regulating valves under great heads now in use, and certainly will be the best when the new models come out. There is no detailed scientific description of these valves as far as known to the writer.

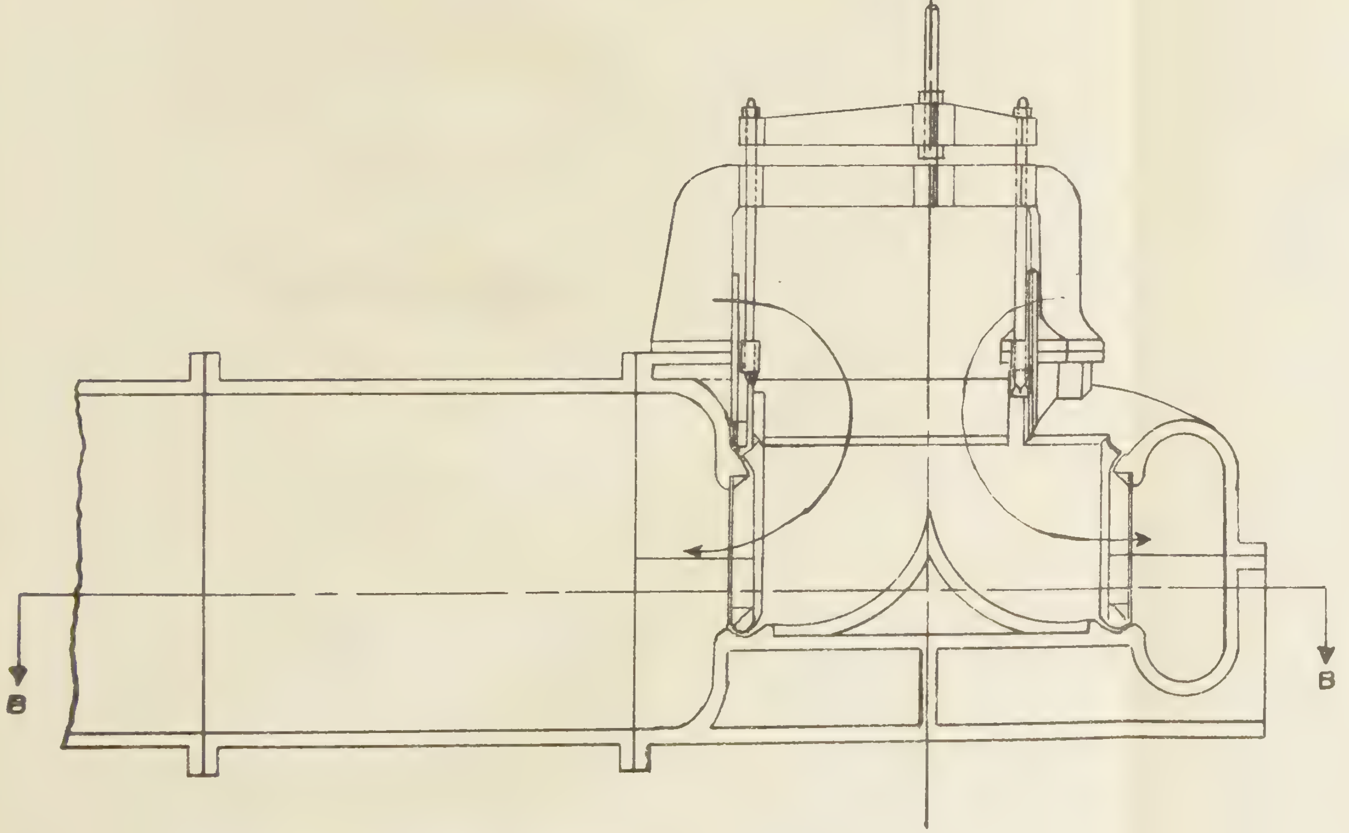
In designing the cylindrical valves now in question there was not in view to devise a valve or type of gate to take the place of the regulating valves, or to be used as regulating valves at all, but to arrive at some type of gate or valve of medium cost, upon the surfaces of which fluid pressures in every direction may be balanced or in equilibrium, to be used as sluice and guard gates under considerably greater heads than practicable for slide gates; and especially adapted for use for guard gates to the Ensign or Teichman regulating valves, and which may be capable of being conveniently operated under all heads for which slide valves are designed and used. They are not yet (experimental data wanting) considered by me as suitable for use in intermediate positions between open and closed; in other words, for regulating discharge, on account of disturbances that may be expected to be set up by partial vacuums due tortuous course of water through them under high velocities, and the probable hammering due the formation, destruction, reformation, etc., of such vacuums about the edges of the cylinders if not very securely held by close fitting guides. They can, however, be opened and closed in front of the regulating valves in high current velocities, if it be found necessary on account of wedging or failure of such valves, under circumstances where slide valves or gates are impossible of operation, and also for emergency discharge gates and sluices, when close regulation is not necessary, or when for any cause the corresponding regulating valve is await-



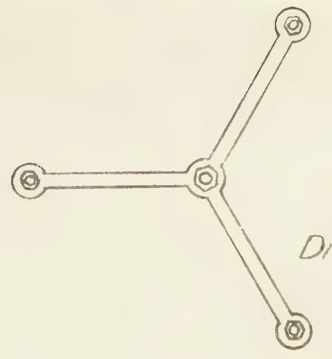
TOP VIEW
Crosshead removed



SECTION B-B



SECTION A-A
Valve closed



TOP VIEW OF CROSSHEAD

Department of the Interior
United States Reclamation Service
HOODLESS CYLINDER VALVE
Discharging through one end and under the other
end of an open cylinder, which constitutes
the movable part of the valve
PROPOSED BY
GENERAL WILLIAM L. MARSHALL
Consulting Engineer
To Secretary of the Interior
1913

ACCESSION NO 15128

ing repairs. They may all be made water-tight when closed, by very simple devices already in use with cylindrical valves.

The single discharge types, and the double acting valves shown in concrete setting are designed for small heads mainly, but in all types, except that one shown as attached to a pipe elbow (see Plate, Accession No. 15131), the discharge is through the hollow cylinder, and there is no housing or hood required in any of them as in the Fontaine low cylindrical valves used at Panama and for forty years or more elsewhere in this country or abroad. The drawings show types only, and all minor things like packing, etc., are omitted to avoid confusion. It is unnecessary to show devices well understood to be common to all close fitting valves.

None of these valves is in use; in fact, they are novelties published just now for what they may be worth in considering projects requiring guard and sluice gates of large capacity under considerable heads. They will doubtless be used, if found useful and advantageous, otherwise they will remain as part of the record of attempts at solving a serious problem in hydraulic engineering that must be solved in some way. Now that they are born, their parent has little interest in them further than to claim and be responsible for them as his progeny and to protect the United States against possible claims of pseudo inventors, by publication. The writer believes that the slide gates for large sluices, and for guard gates, under high pressures must go, and that some form of plain, positively operated cylinder or balanced gate will be substituted therefor for closing outlets greater, say, than 20 square feet under high heads, but any of the known cylindrical valves may be made automatic if the expense justifies.

Of the valves proposed herein one form only is of any considerable interest, that is, the ''double entry'' valves (Plates, Accession Nos. 15127 and 15129) wherein a section of a hollow right cylinder with circular bases is inserted in an annular housing, and closes or opens the inner sides of the inclosing hollow ring. When the cylinder (supposed submerged in water) is raised from its seat a distance equal to one-half or more of its diameter, the liquid discharges into the hollow ring and out through the discharge pipe not only through the interior of the hollow cylinder but also through the hole at the bottom of the ring heretofore closed by the surface and the base of the cylinder, giving a discharge equal to that of two orifices of capacity equal to the inner section of the cylinder. This form is interesting in two ways:

1. It may give the greatest possible discharge with the least possible valve movement, and with minimum weight of moving parts and with least frictional resistance. 2. Under very high heads the disturbance at the bases of the cylinder and in the the ring might be found dangerous to the material and the surfaces of the casing might be rapidly eroded by gritty water under the increased velocities, if the full discharge under such head were allowed to pass the valve. In such case the velocities in the valve and casing can be cut down to any extent by reducing the size of the discharge pipe so as to cut down the discharge through the valve itself when wide open to well below the capacity of the valve under that head.

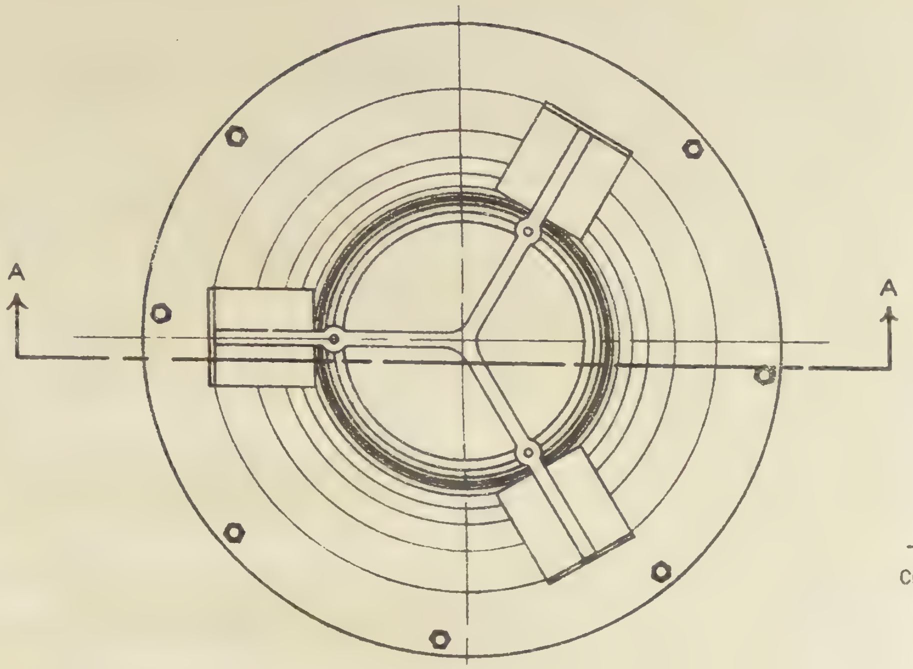
Thus, if the valve were barely capable of safely and smoothly discharging to its full or duplex capacity at 100-ft. head, and it be in question to use it at, say, 400-ft. head, under which head the velocity would be doubled and the wearing energy quadrupled, it would be necessary for safe and smooth action to reduce the capacity of the discharge pipe to one-half the capacity of the valves under the full head of 400 feet. This would result in bringing down the velocities, pressures, etc., in the valve and casing when fully opened to the same values as at 100-ft. head, with precisely the same discharge, the velocity in discharge pipe being doubled and the capacity of the pipe at same time reduced one-half.

In similar manner the valve may be adjusted to its greatest safe discharge capacity, at any head, by adjusting the capacity of the discharge pipe or conduit.

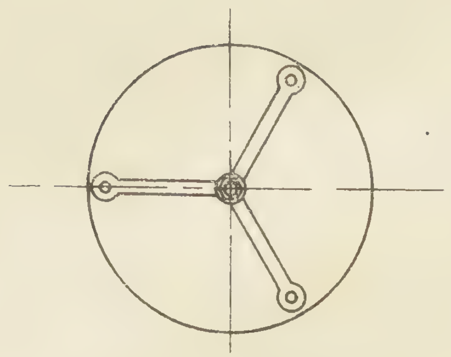
The valve is therefore practicable through a wide variation in maximum heads due its position in the reservoir, by varying the discharge pipe to give equal discharges at such varying maximum heads, or positions. Other types, of course, may be treated likewise, but under similar conditions of adjustment, etc., the form in question will always give approximately twice the discharge of any other type of cylindrical valve of same diameter.

MOVABLE CRESTS.

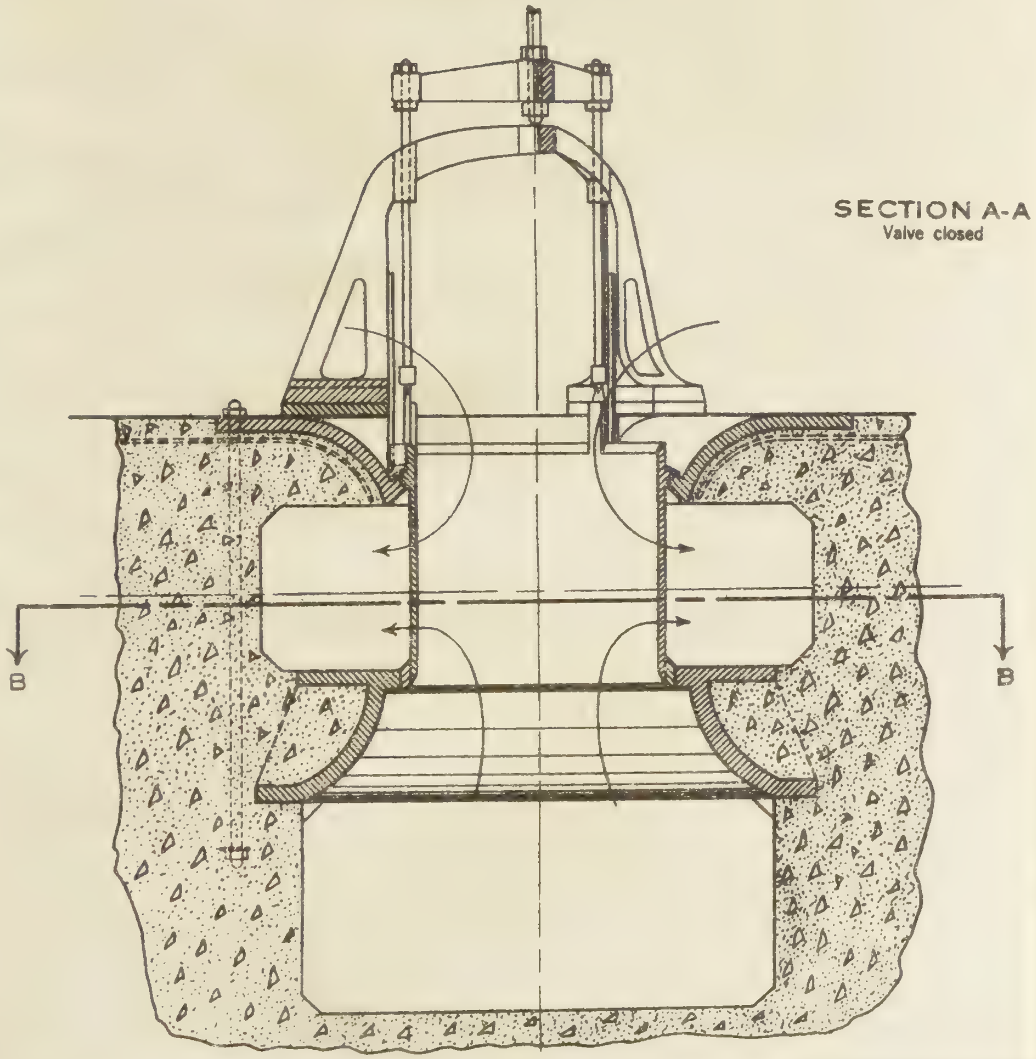
The types shown are not all novel; the two types at the top of the drawing are covered in whole or in part by a patent granted me in 1898. The straight or plane gate type (Accession No. 15184, upper left hand figure), modified to suit local conditions, is in use since 1907 on the Feeder of the Illinois and Mississippi Canal near the



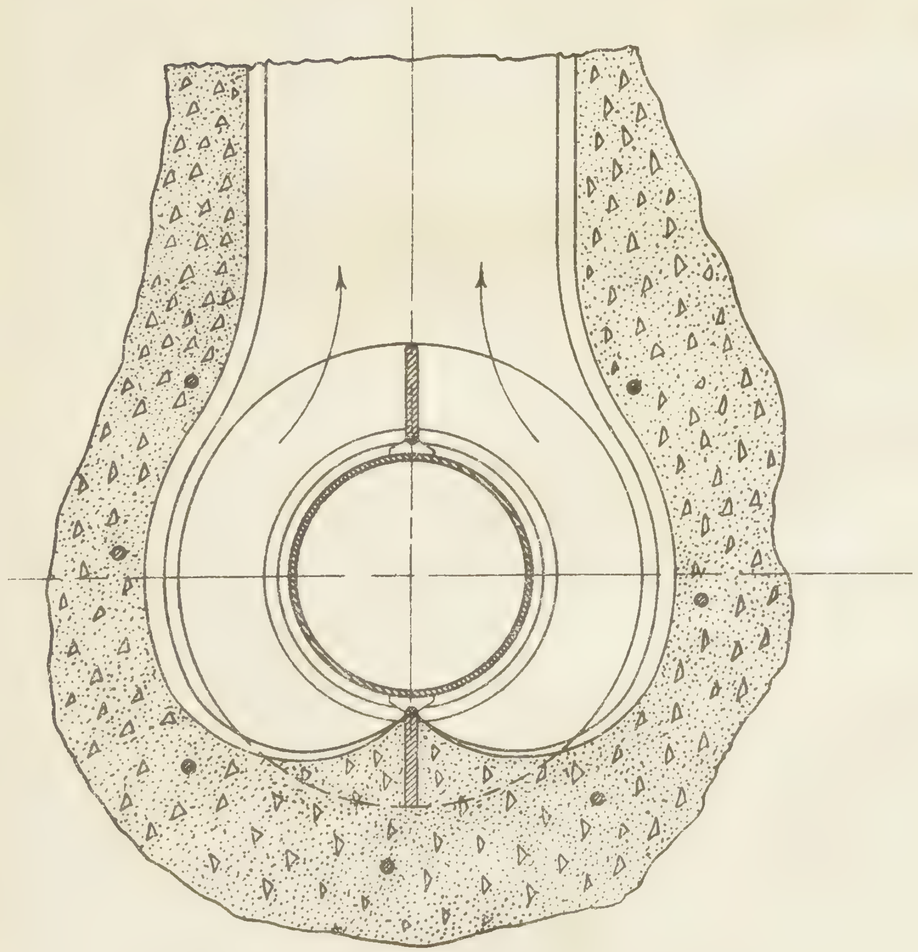
TOP VIEW
Crosshead removed



TOP VIEW OF CROSSHEAD



SECTION A-A
Valve closed



SECTION B-B

NOTE
THIS DRAWING ILLUSTRATES THE APPLICATION OF THE VALVE TO A SETTING IN CONCRETE.

DEPARTMENT OF THE INTERIOR
UNITED STATES RECLAMATION SERVICE

BALANCED VALVE

GIVING MAXIMUM DISCHARGE.
WITH MINIMUM MATERIAL AND WITH LEAST MOVEMENT
POSSIBLE IN PROPORTION TO DISCHARGE
PROPOSED BY
GEN. WILLIAM L. MARSHALL
CONSULTING ENGINEER
TO SECRETARY OF THE INTERIOR
1913

ACCESSION NO. 15129

aqueduct crossing Green River.* It is placed horizontally in the bottom of the Feeder as an emergency stop gate, to rise and retain the canal level in case of a break in the banks. The particular gate was designed by Mr. Christopher Holth, Mechanical Engineer, and constructed by Mr. L. L. Wheeler, Assistant Engineer. The canal bank broke in 1910 and the gate automatically rose and closed the Feeder, retaining the level in the Feeder canal. It then repaid its cost.

The second type at top of plate (without the wooden drift shield and siphon) has also been in use, since 1907, as upper gates on 14 locks on the Illinois and Mississippi Canal, but the lower leaves or aprons of those gates were designed of sufficient size only to depress the gates automatically when the locks are filled to within 10 inches or less of the surfaces of the upper pools. Those gates have worked successfully since 1907, although there were defects in workmanship that were corrected, and at least one uncorrected defect in design that is of no practical importance so long as the canal levels are maintained. These gates were also designed under my patents by Mr. Holth, but the completed designs were not submitted to me for correction. This type requires flotation or auxiliary power to raise it until its nose is above water, when the current may act. It may be readily modified to be applicable to spans up to 100 feet, but is peculiarly adapted for use as an upper gate to a canal lock, of 40 feet or less span, and not exceeding 10 to 12 feet depth.

The two types at the bottom of the plate are believed to be novel, and are—like the valves—now published for what they may be worth. They may be used by the United States freed from patent claims. Anyone familiar with "bear traps" will understand at a glance their working. The only features worth special remark are:

1. The care taken to so arrange the hydraulic chambers as to cause mud and sediment to be swept by the motion of the gate into or near numerous water supply and exit pipes or "scuppers," and sufficient leakage to keep mud from accumulating. This leakage may be reduced to any extent by well proven means.

2. The arrangement of piping for above purposes, and to secure uniform distribution of water pressures along entire length of gates

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*See illustrated article on "The Emergency Gates of the Illinois and Mississippi Canal," by Maj. P. S. Riché, Corps of Engineers; page 327, PROFESSIONAL MEMOIRS, 1910.—ED.

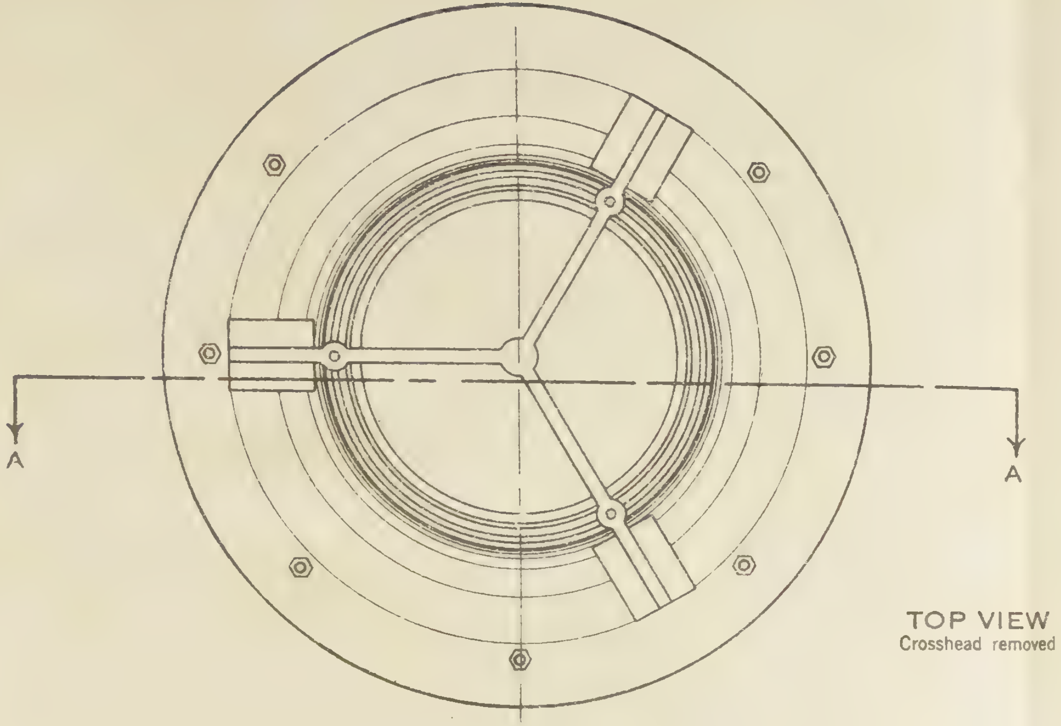
by making main conduits of much greater capacity than that of all distributing pipes or conduits combined.

3. The siphon for automatic control of the gates during floods, in connection with or rather in addition to hand control. These siphons "bleed" the supply mains before water in them may reach under pressure the small distributing pipes leading into hydraulic chambers, and have discharge capacities nearly equal to but less than the main conduits, so that (if the hand operating devices be closed) whenever during a flood the water level above a dam reaches the level of the siphon throat or top, the siphon at once so "bleeds" the supply main that the preponderance of water pressure is at once changed from one side to the other of the axis of rotation of the gate, and it will fall and remain flat until the level in the reservoir falls below the air inlet to siphon, whereupon the siphon action is broken, the full pressure is again exerted throughout the surface of the gate, the preponderance of pressure is again shifted from one side to the other of the axis of rotation, and the gate rises.

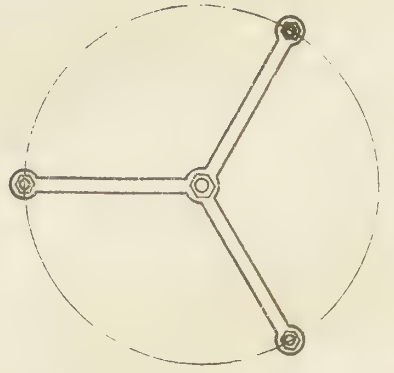
The type with siphon control falling down stream admits trussing or bracing, etc., so that it is possible to make it very light, and at the same time strong and stiff against warping and of any reasonable length. It may be advantageously used up to 10 to 12 feet lift on high spillways and dams. The width of that part below the axis of rotation in any of these movable crests should be not less than five-eighths the width of upper section, exclusive of width of flap leaf; the relative proportions of parts of gates should be computed to meet the special conditions in each case.

Steel plates are hinged to edges of lower sections and move along inclined planes in order that there shall be elasticity in the system even under considerable wear at axis and inaccurate work. The gates will not be subject to wedging and obstruction by gravel, chips, etc., and these narrow leaves remove most of the objections that have been made to drum weirs, etc., the leaves of which must be nearly in contact with the curved surfaces of hydraulic chambers, and are often wedged. These plates may be in sections of desirable lengths, the joints between lengths may be stopped against leakage by strips of pure rubber packing, allowing any section to rise or descend enough to pass over any chance pebble or chip without serious leakage, or straining the gate, and the plates as a whole to adjust themselves to wear or inaccurate workmanship, location of axis or in forming the plane surfaces of the hydraulic chamber.

4. The air passages to remove vacuums that form under the gate, due rapid flow of water over it when down, are not novel, except in the particular disposition of them. Vacuums more or less complete under overfalls increase materially the pressures on the upstream faces of gates and dams; cause tremblings and vibrations in dams, and in old bear-trap forms sometimes determine whether they can be worked at all in certain positions or phases of their motion.

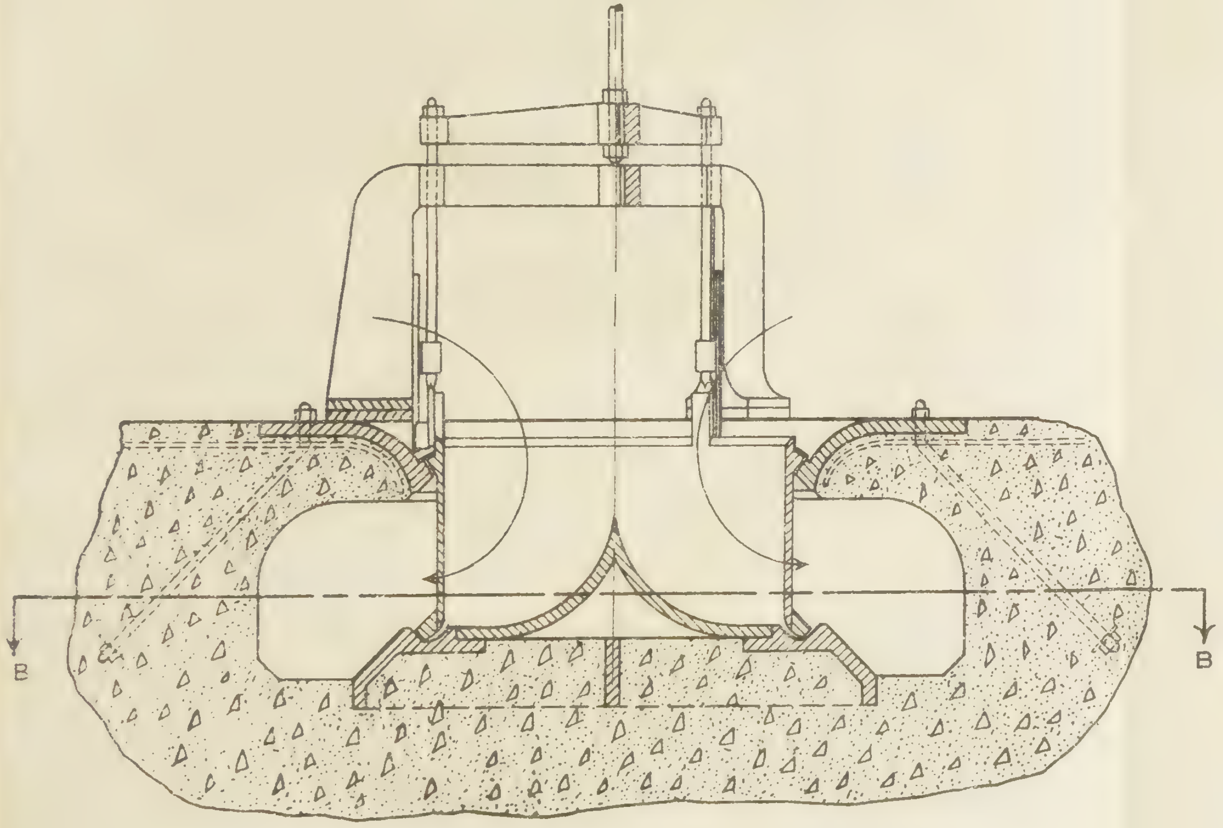


TOP VIEW
Crosshead removed

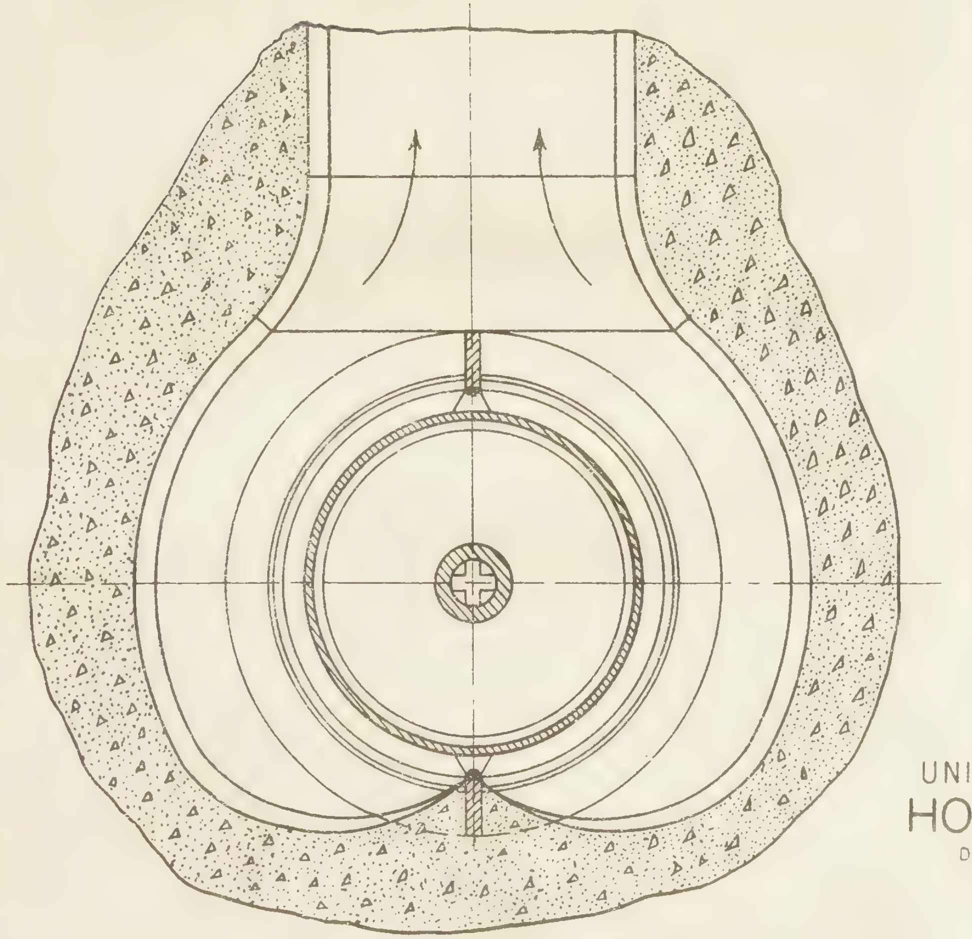


TOP VIEW OF CROSSHEAD

NOTE
THIS DRAWING ILLUSTRATES THE APPLICATION OF THE VALVE TO A SETTING IN CONCRETE.



SECTION A-A
Valve closed



SECTION B-B

DEPARTMENT OF THE INTERIOR
UNITED STATES RECLAMATION SERVICE

HOODLESS CYLINDER VALVE

DISCHARGING THROUGH ONE END AND UNDER THE OTHER
END OF AN OPEN CYLINDER, WHICH CONSTITUTES
THE MOVABLE PART OF THE VALVE

PROPOSED BY
GENERAL WILLIAM L. MARSHALL
CONSULTING ENGINEER
TO SECRETARY OF THE INTERIOR
1913

ACCESSION NO 15130

The question of prevention of partial vacuums, then, is of some importance in all dams, whether movable or fixed, and especially so in bear-traps, where little or no attention has been given the subject.

REGULATION OF LEVELS OF RESERVOIRS WITH HAND OPERATED AND AUTOMATIC HYDRAULIC SPILLWAY CRESTS, OR SLUICEWAY GATES.

Some criticisms of automatic movable sluice gates have been based upon the opinion that their movements are so rapid that there would be thrown into the stream below the reservoir large amounts of water en masse, thus creating waves of such magnitude that damage to animal life, or to property, might result.

This objection is well founded, but that it may be easily removed is evident when it is considered that the movable crests, or spillway gates proposed are in fact hydraulic engines, capable, if properly constructed, of as smooth, gradual and certain movement and control (and by similar methods) as any other hydraulic press or engine.

It is necessary for this purpose in a series of sluiceways controlled by automatic gates to provide one and only one sluiceway of the series, with a hydraulic gate to be operated carefully by hand, in order to make the increase in discharge as gradual as it would be over a fixed or movable horizontal weir of suitable length, by filling in by gradual increase in discharge the differences in total discharge caused by the sudden periodic gate movements.

For instance, suppose there is an available site 350 feet in length for a spillway to be used in connection with a large reservoir, and that the maximum flood to be wasted is about 25,000 s. ft. and it be desired to store all water practicable in the reservoir, with a fluctuation in its water level of about 2 feet.

The effective depth of the sluiceways, if 50 feet wide each, must be 9 feet at maximum flood level, and there must be six of such sluiceways of that width to discharge the maximum flood of 25,000 s. f.

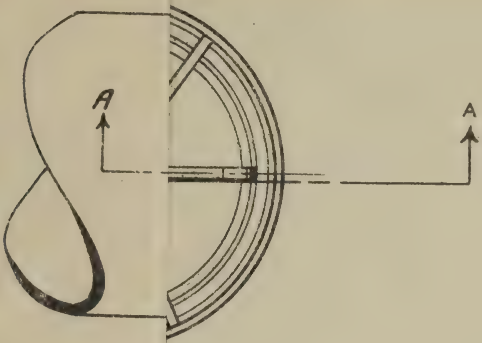
The sluice gates or movable crests may be made of 7-ft. lift each, and the water levels in the reservoir must be so controlled as to rise not more than 2 feet above their crests when raised.

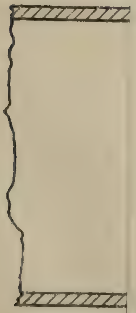
Each 50-foot sluiceway 7 feet deep will discharge approximately 3,000 s. f. When the water rises to the limit assumed there will be 9 feet depth in the sluices and the discharge of each will then approximate 4,500 s. f. The discharges may be less than above given, but they are assumed for the purposes of a demonstration; accuracy is not now in question.

One of the sluice-gates is to be of most careful construction, and fitted in all its parts for hand control and operation, and five of them are supposed to be operated automatically by siphon, all gates being of a type falling down stream from the reservoir. These latter have the siphon throats and their air-entrance breaks adjusted in level so that the gates will fall in succession, upon increments of say about 3 inches in reservoir levels, beginning with the first gate falling when that level reaches 7 inches above the crest when raised, and the last or sixth gate falling when the water level of the reservoir is about 3 inches below the maximum safe limit named above. Now, when the water level in the reservoir rises until it is nearing 7 inches above the crests of the gates,—at which level the first gate is arranged to fall,—the operator would begin to lower the hand-operated gate at a rate that preserves the level of the reservoir water until that gate be fully depressed.

Whenever the first automatic gate goes down, the hand-operated gate should at once be raised, and the same gradual movement of the hand-operated gate be resumed between the falling of the first and second, etc., and succeeding automatic gates, if such care be necessary. It is, then, practicable to make the discharge from a reservoir by the use of these gates, or indeed of any of the ''bear-trap'' family, as gradual and regular as by any other device, even if that device be a fixed weir, but the controlled sluiceways have the material advantage over the fixed weir of allowing the storage of 7 feet (in this case) depth of water over the entire surface of the reservoir, which can not be done by a fixed weir of same length of crest with as little waste and as little fluctuation in water level in the reservoir, and the sluices moreover, serve admirably for drift chutes.

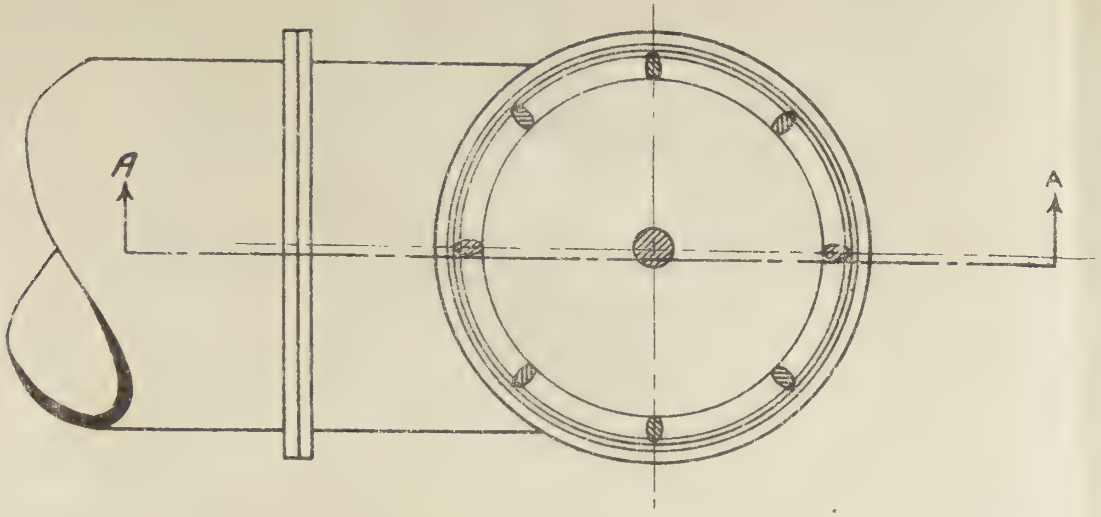
In some very large reservoirs now in existence, or under construction, this additional storage of 7 feet in the reservoir might run to a hundred thousand acre-feet or even much more, a matter of very great importance in our arid region, where water is so precious for irrigation and domestic use.



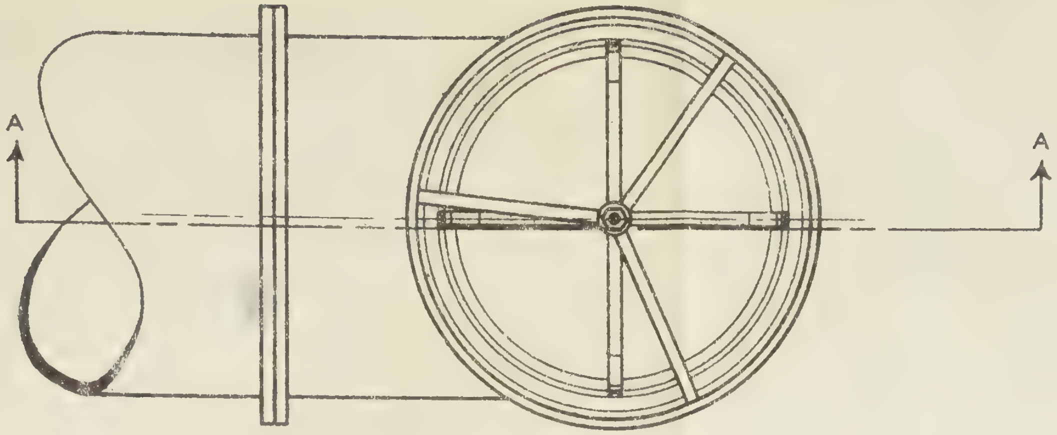


DEPARTMENT OF THE INTERIOR
UNITED STATES RECLAMATION SERVICE
HOODLESS CYLINDER VALVE
PROPOSED BY
GENERAL WILLIAM L. MARSHALL
CONSULTING ENGINEER
TO SECRETARY OF THE INTERIOR
1913

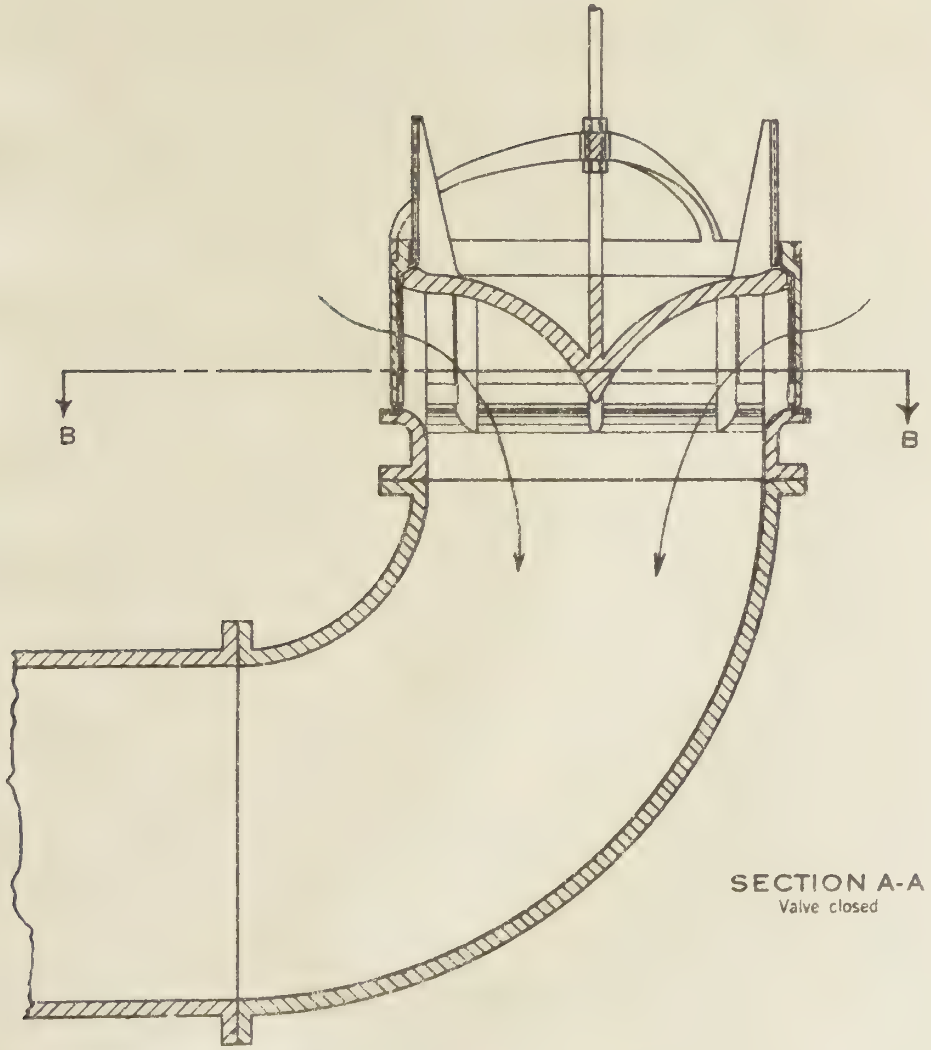
ACCESSION NO. 15131



SECTION B-B



TOP VIEW



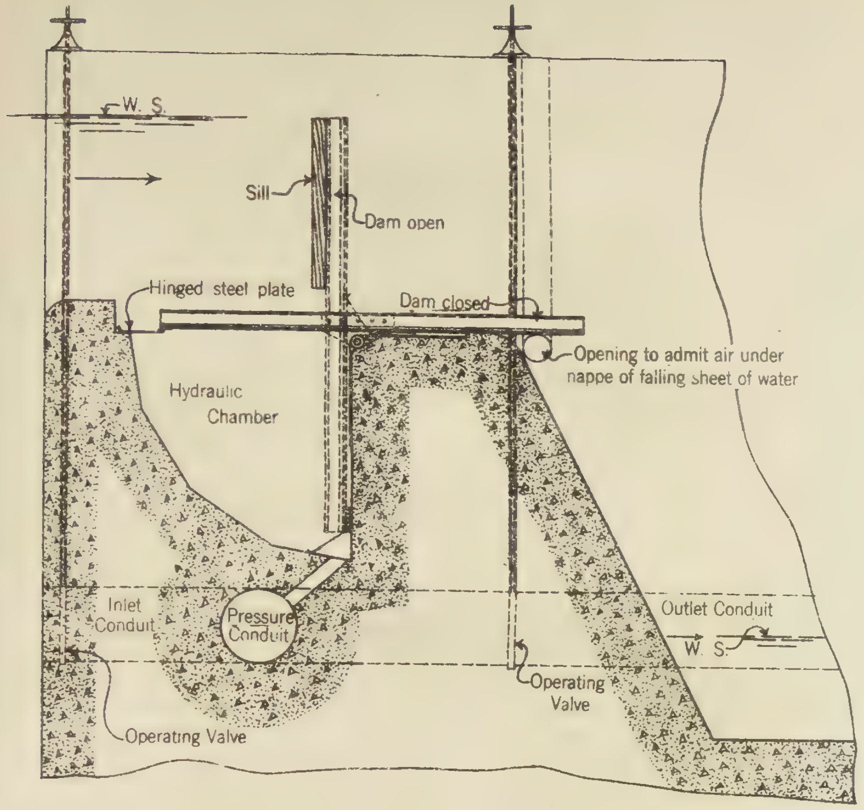
SECTION A-A
Valve closed

NOTE

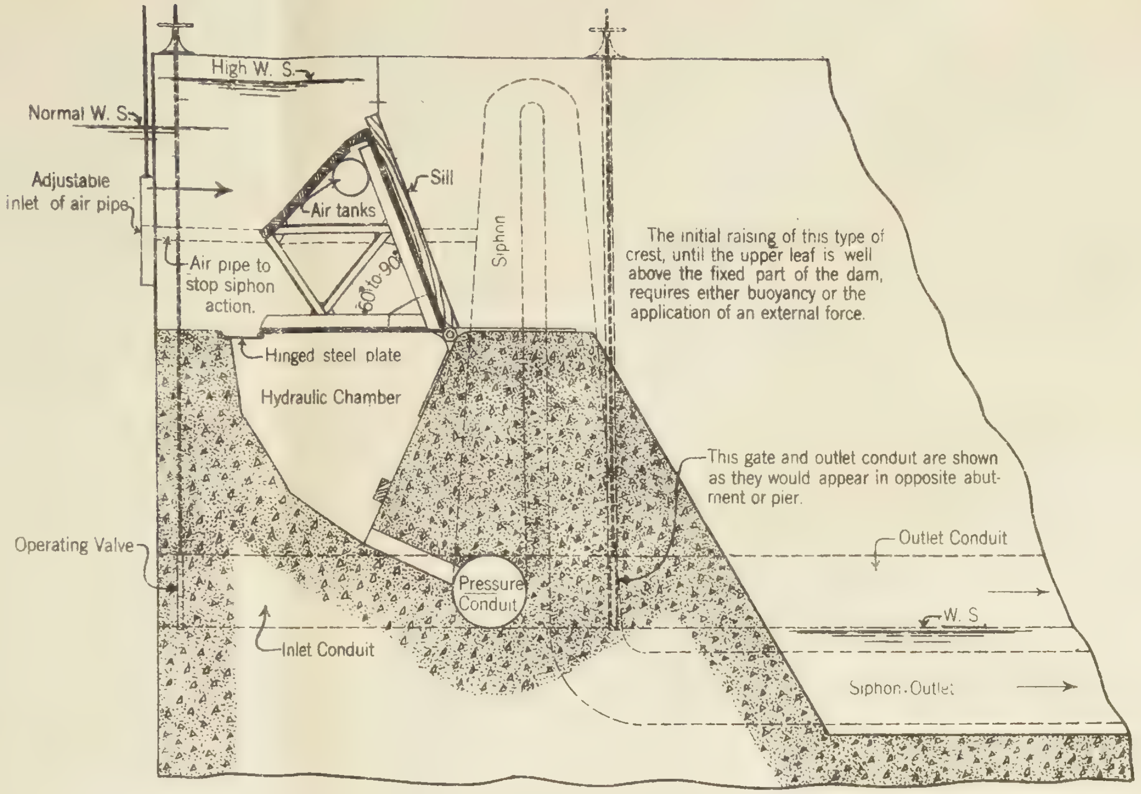
THIS DRAWING ILLUSTRATES THE APPLICATION OF THE VALVE TO A SETTING ON A PIPE ELBOW.

DEPARTMENT OF THE INTERIOR
UNITED STATES RECLAMATION SERVICE
HOODLESS CYLINDER VALVE
PROPOSED BY
GENERAL WILLIAM L. MARSHALL
CONSULTING ENGINEER
TO SECRETARY OF THE INTERIOR
1913

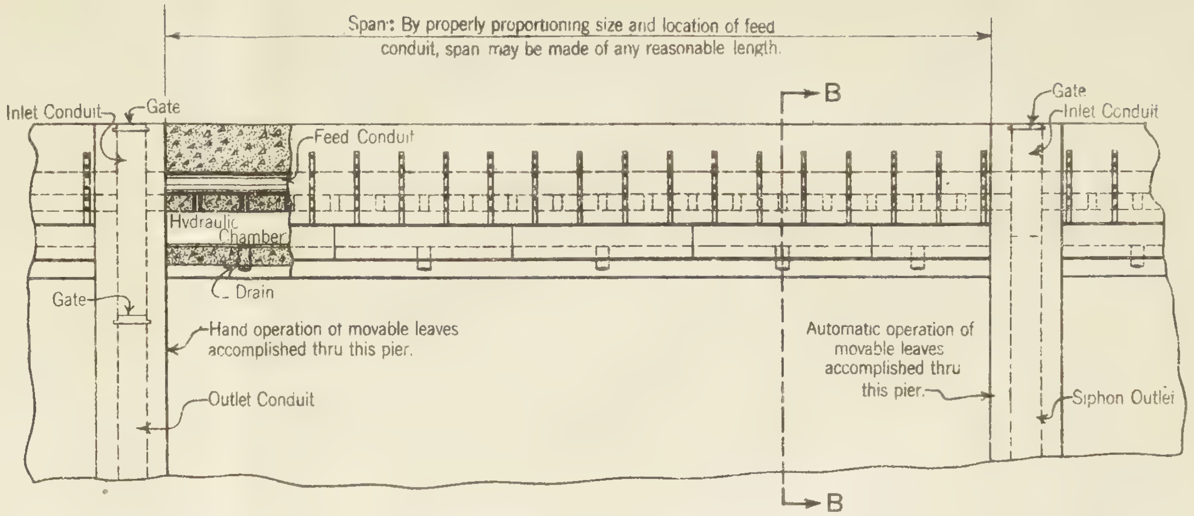
ACCESSION NO. 15131


W. S.
Sill
Dam open
Hinged steel plate
Dam closed
Opening to admit air under nappe of falling sheet of water
Hydraulic Chamber
Inlet Conduit
Pressure Conduit
Outlet Conduit
W. S.
Operating Valve
Operating Valve

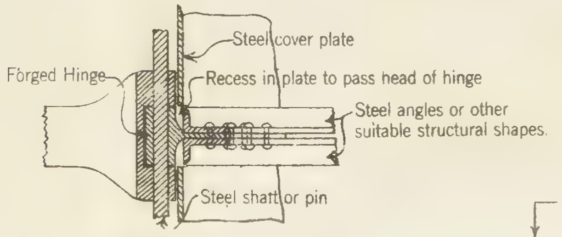
TYPE OF GATE FALLING DOWNSTREAM


High W. S.
Normal W. S.
Adjustable inlet of air pipe
Air pipe to stop siphon action.
Air tanks
Sill
60 to 90°
Siphon
The initial raising of this type of crest, until the upper leaf is well above the fixed part of the dam, requires either buoyancy or the application of an external force.
Hinged steel plate
Hydraulic Chamber
This gate and outlet conduit are shown as they would appear in opposite abutment or pier.
Operating Valve
Outlet Conduit
Pressure Conduit
W. S
Inlet Conduit
Siphon Outlet

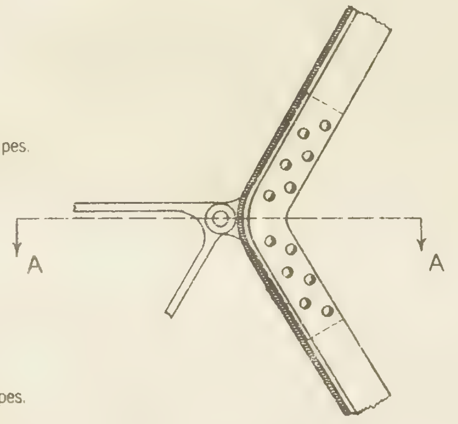
TYPE OF GATE FALLING UPSTREAM


Span: By properly proportioning size and location of feed conduit, span may be made of any reasonable length.
B
B
Inlet Conduit
Gate
Feed Conduit
Gate
Inlet Conduit
Hydraulic Chamber
Drain
Gate
Hand operation of movable leaves accomplished thru this pier.
Automatic operation of movable leaves accomplished thru this pier.
Outlet Conduit
Siphon Outlet

PLAN

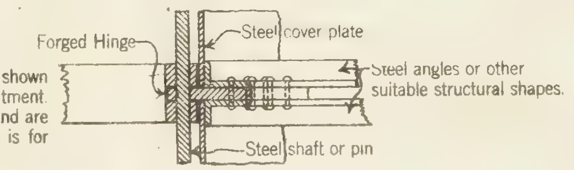

Steel cover plate
Forged Hinge
Recess in plate to pass head of hinge
Steel angles or other suitable structural shapes.
Steel shaft or pin

SECTION A - A

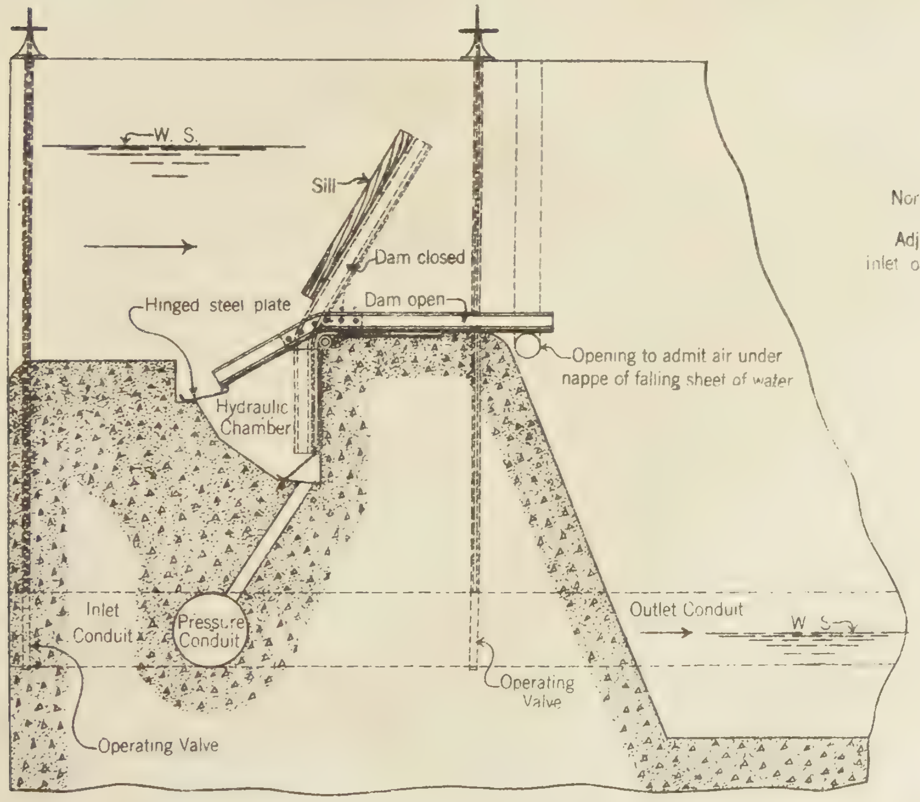


DETAIL OF HINGE

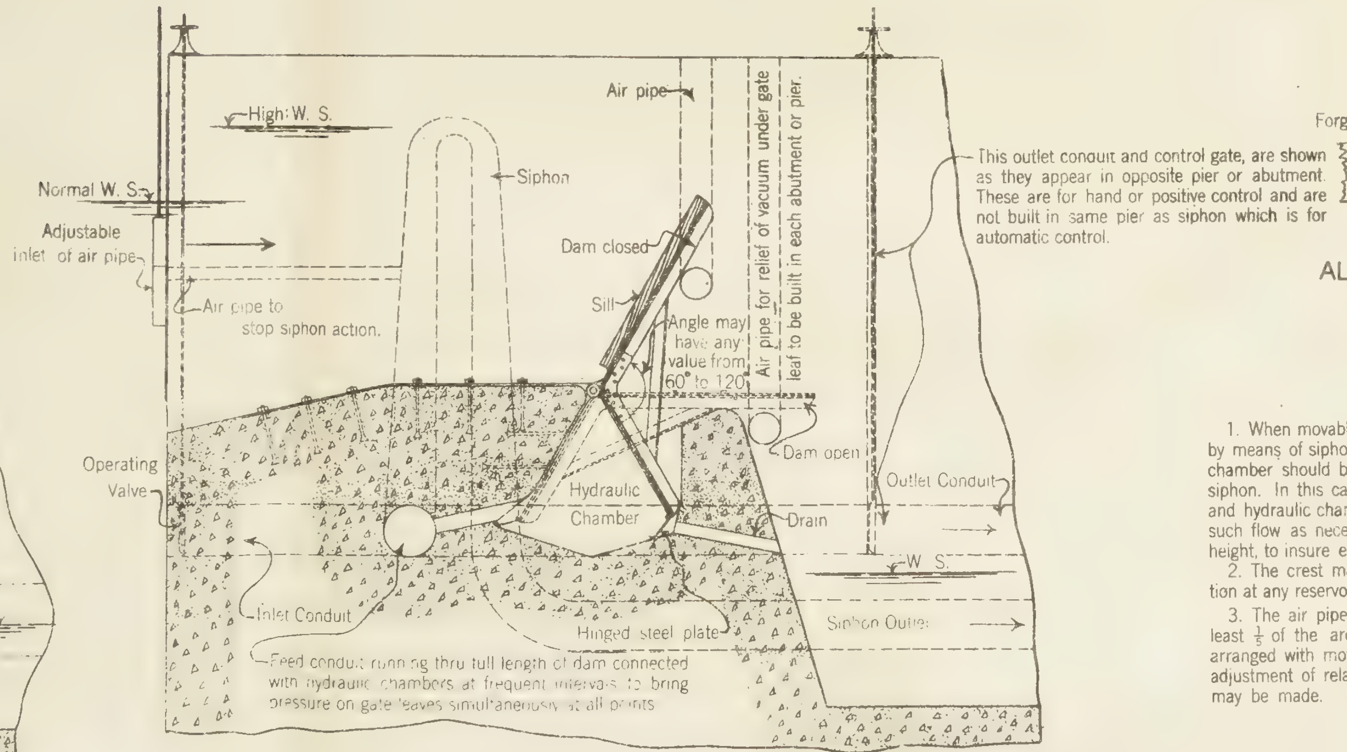
Hinges placed at intervals of about 5 feet thruout length of dam.


Forged Hinge
Steel cover plate
Steel angles or other suitable structural shapes.
Steel shaft or pin

ALTERNATE TYPE OF HINGE


W. S.
Sill
Dam closed
Hinged steel plate
Dam open
Opening to admit air under nappe of falling sheet of water
Hydraulic Chamber
Inlet Conduit
Pressure Conduit
Outlet Conduit
W. S.
Operating Valve
Operating Valve

TYPE OF GATE FALLING DOWNSTREAM


Air pipe
High W. S.
Siphon
Normal W. S.
Adjustable inlet of air pipe
Air pipe to stop siphon action.
Dam closed
Sill
Angle may have any value from 60° to 120°
Air pipe for relief of vacuum under gate leaf to be built in each abutment or pier.
This outlet conduit and control gate, are shown as they appear in opposite pier or abutment. These are for hand or positive control and are not built in same pier as siphon which is for automatic control.
Dam open
Operating Valve
Outlet Conduit
Hydraulic Chamber
Drain
W. S.
Inlet Conduit
Hinged steel plate
Siphon Outlet
Feed conduit running thru full length of dam connected with hydraulic chambers at frequent intervals to bring pressure on gate leaves simultaneously at all points

TYPE OF GATE FALLING DOWNSTREAM
SECTION B - B

NOTES

1. When movable crest is to be operated automatically by means of siphon, all conduits leading to the hydraulic chamber should be closed except such as connect with siphon. In this case the inlet conduit leading to siphon and hydraulic chamber should be adjusted to admit only such flow as necessary to maintain crest at maximum height, to insure effective action at siphon.

2. The crest may be raised or lowered by hand operation at any reservoir height

3. The air pipe to break siphon action should be at least $\frac{1}{5}$ of the area of siphon throat, and its entrance arranged with movable mouthpiece in order that proper adjustment of relative levels at which the dam is to act may be made.

DEPARTMENT OF THE INTERIOR
UNITED STATES RECLAMATION SERVICE

TYPES OF
MOVABLE DAM CRESTS

PROPOSED BY
GENERAL WILLIAM L. MARSHALL
CONSULTING ENGINEER
TO SECRETARY OF THE INTERIOR
1914

ACCESSION NO. 15184

Tank Car Water Supply for Troops on the March

BY

Lieut. O. N. SOHLBERG
Corps of Engineers

On the recent seven-day march of the Second Division from Texas City to Houston, Tex., and back, the entire water supply for the troops and the animals was furnished from railroad tank cars. In view of the possibility that this method of water supply might be resorted to were a march to be undertaken from Vera Cruz to Mexico City, or from the Rio Grande south, the little information gathered on this trip may be of interest.

The water supply problem was handled by the chief Engineer officer of the division, as properly this problem should be handled either in camp or on the march. In a case like this only the transportation should be tended to by the quartermaster department.

At no halt but one did there exist a pump and storage tank of sufficient capacity to supply the water needs of the division. The route of march was parallel to a railroad. Railroad tank cars were available in Houston, where they could also be properly cleaned and filled with water.

Tank cars that had been used in the cotton oil service were selected for two reasons. These tanks are much more easily cleaned than those having contained crude petroleum; and secondly, any trace of cotton-seed oil in the water is less evident and obnoxious to the taste than that of petroleum. For the same two reasons, stated above, in selecting tank cars for conversion to water service those that have been in the following services, in the order named, are the most desirable if available: molasses, cotton-seed oil, glycerine, refined petroleum, crude petroleum.

As to cleaning such tanks the requisites are live steam, concentrated lye, and water. First of all, men enter the tank and thoroughly scrape the insides clean of all deposits. This muck is washed out by water. Steam is then let in, and the higher the temperature of the steam the better its cleaning action, which is important in reducing the time required to keep the tank under steam. The tank is cooled until men may again enter to scrub the insides with a concentrated solution of lye. The tank is steamed out a second time. It may be necessary to repeat the scrubbing process, followed by another steaming out. This is usually the case with crude petroleum tanks. Clear water is next introduced to thoroughly rinse the container, which should leave it in condition not to contaminate water placed in it. It requires, on the average, the time given below for cleaning each car used in the cotton-seed oil service. For crude petroleum tanks the time of a second scrubbing and a third steaming out may be added.

Two hours scraping out insides and cleaning out muck.
Four hours under live steam.
Five hours cooling, if air is used.
Two hours, if water is used.
Three hours scrubbing with lye.
Four hours under second steam.
Five hours cooling, if air is used.
Two hours cooling, if water is used.
One hour rinsing out and filling.

Total: twenty-four hours if tanks are cooled with air after steaming; eighteen hours if tanks are cooled with water after steaming. The above process would apply to all tanks regardless of previous contents, except that in cleaning tanks that have been used for the transportation of crude petroleum they should be kept under steam longer and scrubbed with a stronger solution of lye, and given an extra scrubbing and steaming. Ten pounds of lye should thoroughly clean an eight or ten thousand gallon capacity car where it has been used in the cotton-seed oil service. This amount should be increased to 15 pounds for cleaning a fuel oil or crude petroleum tank.

From this it is evident that the time required to clean a certain number of tanks depends upon the number that can be cleaned at one time. If time is limited a simple layout is to place as many cars as necessary on two parallel tracks. Lay the main steam pipe between these tracks with a branch connection opposite each tank car. After steaming, water can be introduced through the same pipes.

Circular 6-H of United States and Canadian Railroads shows capacities of tank cars used in the handling liquid freights. Tank cars run from 4,000 to 12,900 gallons capacity. This circular also gives information as to the source of supply of practically all tank cars in the country, with the capacities and class of freights that they are principally used to transport. It will be seen from a study of this that the carrying of petroleum and its products predominates, after which come in order named: chemicals, cotton-seed oil and its products, molasses, and packing-house products. As to tanks available, and proportion of same in the various trades, this will depend upon the time of year required. Take, for instance, the present time, the month of May: Molasses movement is comparatively light and there should be little trouble in getting tanks that have been in that service from the Louisiana railroads. The cotton-seed oil season is practically over and there should be such tanks available from nearly all southern railroads. Crude oil is moving freely at all times owing to the number of railroads and manufacturing plants using it for fuel, but these tank cars are so numerous that there should be no difficulty at any time in securing a required quota. As to tank cars used for hauling water, these are principally, if not altogether, used by the railroads for operating purposes, such as transporting water in arid portions of the country, supplying stations, section houses, bridge gang outfits, and in work train service. These tanks could not be spared to any extent without crippling operating service. According to the best information obtainable, the railroads would charge about $1.00 per car per day rental.

The easiest and most suitable way to empty the cars was found to be by gravity through the valve connection on the under side of the tank, using a mill hose to carry the water to the watering troughs or G. I. cans that were hauled on escort wagons and used for cooking and drinking water. Since the commercial method of emptying is by pumping or forcing the contents out of the dome of the tank, it was found that nearly all of the cars were lacking in bottom connections. It is essential that every tank, after cleaning, should be properly fitted with connections, so that when the car reaches its destination it is only necessary to screw on the hose and turn the valve for operation. Every car used was found to have a large cap covering the bottom outlet. Through this cap was a 2-inch hole. Into this was fitted a 2-inch nipple, then an elbow, and again a 2-inch nipple giving a right-angle turn in the pipe connection so as to avoid the same in the hose. For each car there should be two 50-foot lengths of 2-inch mill hose. Ordinarily one length will be sufficient, but cases may arise where obstacles close to the siding will prevent wagons from driving up near the tank cars. A hose of 100-foot length should be sufficient to bridge any such ditch or obstacle.

If properly regulated there will be found no crowding or confusion in watering all the animals and supplying cooking and drinking water, besides commissaries and forage, to a division at one siding. The units will water their animals and obtain water for cooking in the order that they arrive in camp. But for evening and morning watering there should be a time schedule, giving the limits to the periods when each organization should water their animals. This will avoid any crowding. After the morning watering is over the hose can be disconnected and loaded on the first wagon in the line of march for that day. Along with this is loaded a few extra pipe connections that it is well to carry, and two stillson wrenches. This wagon will arrive at the next camping place in plenty of time to make the connections on the cars, that have been previously placed there, and be ready for operation when the first call for water is made. The watering troughs are loaded on a flat car and, along with the partially unloaded commissary and forage cars, is switched to the siding nearest the next camp.

Some very useful data was collected as to the amount of water required by troops and animals on the march. All the water used was drawn from a known quantity for a known strength of command. This gave a very accurate determination of the amounts. Below is a table of the strength of command and the water used. The camp of the night of the 19th-20th was at Houston and the water here was drawn from the city system.

	No. of Troops.	Animals.	Water used.
			Gals.
April 16-17	9,050	2,828	39,231
April 17-18	9,797	3,703	42,142
April 18-19	9,783	3,703	44,288
April 20-21	6,775	1,302	26,192
April 21-22	6,775	1,302	23,212

No strict division was made of tanks, setting aside a certain number for animals and another for troops, and for this reason exact data can not be given as to the proportion used by each. However, at the third camp out it was possible to make a very close estimate of this. Here the animals used up about 24,000 gallons and the troops the remainder, 20,280 gallons. From the table of strength of command this makes the consumption about 6.5 gallons per animal and a little more than 2 gallons per man. It must be remembered that the water used by the troops was for cooking and drinking purposes only. The dates of the march, it will be seen, were April 16th to 22d. The route was over level shell roads, and the average rate of march was about 12 miles per day.

Considering the difficulties that a large body of troops would encounter in procuring a sufficient amount of pure water, especially in a sparsely populated or arid region, or where the quality of the water was doubtful, the numerous advantages of this method immediately appeals to one. Bodies of troops of considerable size will seldom cut loose from a railroad in a campaign march. If marching along such a route the army can be absolutely free and easy as to where to camp, since it does not depend upon the existing water facilities of the country through which it is traveling. Besides this very great advantage, the purity of the water transported is known and there will be fewer changes in its quality. Since the health of troops depends so directly upon the excellency of its water supply this advantage is of prime importance. The work of cleaning, filling, and placing the tank cars will fall on the base, and it will not draw on the strength of the command.

Alexander Dallas Bache

Class of 1825, U. S. M. A.
(*See Frontispiece.*)

BY

Lieut. PAUL SORG REINECKE
Corps of Engineers, U. S. A.

Eugenics contends that the characteristics of the fathers shall be visited upon the sons to the third and fourth generations of them that create them, and that hereditary qualities will be made manifest in thousands of them that even know not its principles. Let us see.

Dr. Benjamin Franklin distinguished himself in the realms of statecraft, diplomacy, politics, science, literature, philosophy, and the newspaper business; he was noted in our own and other lands for his research work along scientific lines,—witness the popular incident of his experiment with the kite, key, and twine. His great-grandson, Alexander Dallas Bache, in like manner became noted for his work in scientific, educational and literary work, and for his numberless researches into unknown branches of human knowledge. Both are men of whom our nation may justly be proud.

Bache was born in Pennsylvania, 1806—July 19, to be exact—and received his "college" education at West Point. He was appointed July 1, 1821, from Pennsylvania, and while a cadet acted as assistant professor in mathematics and chemistry. He graduated first in the class of 1825, and was kept at West Point—a Lieutenant of Engineers—for duty as assistant professor of engineering for a year, after which he served two years on fortification work. While still on this work as a Second Lieutenant of Engineers, he resigned, June 1, 1829, to take the Chair of Natural Philosophy and Chemistry at the University of Pennsylvania. He served as professor at Pennsylvania until 1843, though the service was not continuous.

Two years of this time (1836-1838) he spent in Europe studying the system of education, under the supervision of what subsequently became the Board of Trustees of Girard College, and of which body he was president. After his return from Europe he accepted the superintendency of schools in Philadelphia, and reorganized the educational system of that city. At Girard College he established and conducted a magnetic and meteorological observatory, and his work there in those subjects contributed greatly to the then sum of human knowledge of terrestrial magnetism.

His excellent work in this connection brought him into prominence at home and abroad, and in 1843 he was called upon to take up what became the greatest accomplishment of his life—the Coast Survey of the United States. In addition to possessing the administrative and executive ability to carry on such a great work, he had the scientific qualifications necessary to grasp the importance of and use the opportunities for making observations of natural phenomena connected with the Coast Survey, though not in the narrow sense the precise work of his Department. Thus, he investigated tides, winds, earthquakes, ocean bottoms, magnetism, and explored the Gulf Stream. His numerous reports on these subjects were accepted and highly complimented by scientific authorities and societies at home and abroad, and earned for him the reputation of organizing and carrying on with the greatest of credit one of the largest and most difficult scientific projects ever undertaken up to that time.

During the Civil War he was an active member of the U. S. Sanitary Commission and, through his department, was an invaluable help to the military and naval authorities of the United States in furnishing maps of the coastal territory in which operations were to be carried on, and in furnishing pilots who knew the channels of southern harbors even when the buoys and channel markings were removed.

Bache's other activities were as numerous as those of his great forebear—he was the founder and first president of the American Academy of Sciences, he was regent of the Smithsonian Institution (1843 until his death), he was a member of the Light-House Board of the United States, he was superintendent of the Office of Weights and Measures, and was on numerous harbor boards. Moreover, he was a corresponding and an honorary member of innumerable scientific societies the world over.

When he died, February 17, 1867, after a lingering illness, he was greatly respected and highly esteemed, both at home and abroad, having lived a life full of service to his fellow men, of honor to the Corps, and of devotion to his country.

The Enlargement of Governors Island

BY

MR. HENRY NASH BABCOCK
Assistant Engineer

1. Prior to 1900, this island contained an area of 69.8 acres, surrounded by sea-walls, built at or near low water mark. It was not regarded as an effective modern work of defense, either in construction or in site, and was occupied by two companies of artillery and by the Headquarters of the Department of the East.

2. Under orders from the Secretary of War, July 21, 1900, a Board of Army officers was appointed, consisting of Major-General John R. Brooke, U. S. Army, Colonel George L. Gillespie, Corps of Engineers, and Colonel Amos S. Kimball, Assistant Quartermaster-General, with instructions to recommend plans for additional barracks and quarters, for storing and shipping accommodations, for rearrangement of buildings, and for enlargement of the island. In its report, August 17, 1900, the Board recommended, among other things, the enlargement of the island by building a dike across the shoal southwest of the island at about 2,000 feet from shore, connecting it at either end to the island so as to inclose an area estimated at nearly 90 acres (the area described was, however, about 84½ acres), filling the inclosure with dredgings, building a new dock and dredging to it, repairing an old dock and constructing buildings, at a total estimated cost of $1,595,000. The estimated cost of the part of this work which was subsequently assigned to the Engineer Department was:

Repairing old dock at Castle Williams and transfer of coal buildings	$15,000
Wharf along sea-wall	100,000
Dredging in front of sea-wall, 250,000 cubic yards	100,000
For Enlargement:	
5,800 linear feet of crib dike at $125	725,000
4,000,000 cubic yards of sand filling at 4 cents	160,000
Total	$1,100,000

3. The project was adopted by the Sundry Civil Act, March 3, 1901, with appropriation of $260,000, of which $200,000 was allotted to the Engineer Department for beginning the work assigned to it.

4. Several changes were made in the details of this work from time to time:

a. The plan for inclosing the additional area was changed from a crib dike to a masonry wall on a riprap foundation, on the ground of economy, chiefly.

b. The area of enlargement was increased to 103½ acres, under orders of the Secretary of War, in April, 1902. This required abandoning the riprap already placed in the southwest line of sea-wall foundation—21,754 tons at 35 cents=$7,613.90—the cost of moving the stone being prohibitory.

c. The sand fill, when built above high water, dried out and was blown about in strong winds, depositing sometimes on the slopes of the old island, sometimes in Buttermilk Channel. The fill for the inner 79 acres (all that the funds permitted) was graded, covered with earth, and seeded. The outer 23 acres were built of "cellar dirt," containing enough clay to prevent much drift from winds.

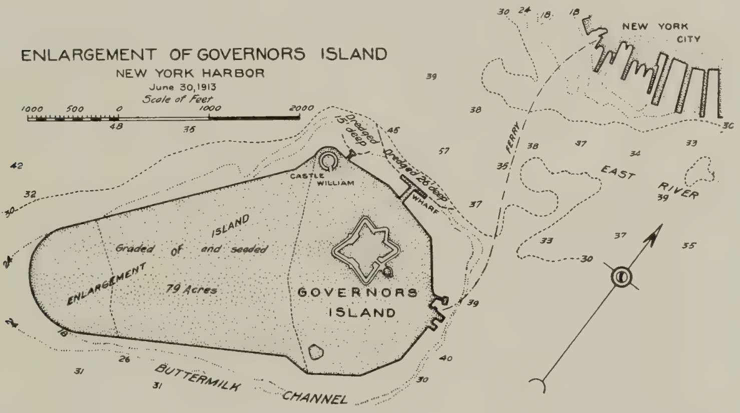

ENLARGEMENT OF GOVERNORS ISLAND
NEW YORK HARBOR
June 30,1913
Scale of Feet
1000 500 0 1000 2000
NEW YORK CITY
FERRY
EAST RIVER
CASTLE WILLIAM
Dredged 15' deep
Dredged 26' deep
WHARF
ENLARGEMENT
ISLAND
Graded of and seeded
79 Acres
GOVERNORS ISLAND
BUTTERMILK CHANNEL

Fig. 1. Governors Island, showing extension. Orginal area, 69.8 acres. Enlargement, 103.5 acres. Total area, 173.3 acres.

d. Sewers from a row of officers' quarters and from other buildings along the southwest side of the island discharged through the old sea-wall. As they would be covered by the embankment, intercepting sewers were laid along that section, discharging on one side into Buttermilk Channel, on the other side into the North River. Cost, $3,209.54.

e. As the riprap for sea-wall was built out into deep water, it became necessary to provide for a light and fog signal. In 1902, a small shed was built on piles near the outer end of the work and the light and fog-bell were maintained there for a few months when the structure was run into by an unknown scow in tow, and was completely wrecked. The signals were then transferred to an old schooner hired for the purpose and moored near the outer end of the riprap, until the embankment was far enough completed, when a small house was built near the wall and used as a lighthouse. After several refusals to assume charge of this station during the period of construction, the Light-House Department finally undertook to take it over, and the house, together with all of the apparatus, was turned over to them May 10, 1912. The entire cost of maintaining light and fog-bell by the Engineer Department from 1902 to 1912 was $10,598.59.

5. Here follows a description of the distinctive parts of the work under this project, in the order in which they were begun:

REPAIRS TO DOCK AT CASTLE WILLIAMS.

6. This was a small dock built out to a crib. It was wholly out of repair and not usable. It was extended to 110 feet from the sea-wall with a T-front 51 feet at 9½-foot depth and the approach was dredged 15 feet deep. Work on dock repair was begun in August and completed September 5, 1901, at a cost of $2,850.00. The dredging was done in September and October, 1901, under a contract to make 15-foot depth over a designated area for $3,850.00; 6,687 cubic yards were removed, making the cost 57.6 c. a yard. Material: sand, gravel, and small stones. Total cost of dock and dredging, $6,700. This was regarded as an emergency work, the dock being required for immediate use. It did not cover the removal of buildings proposed in the original estimate of $15,000.

WHARF ALONG SEA-WALL.

7. The project seemed to contemplate a landing parallel to and near the north sea-wall. Examination showed that the cost of dredging there would be excessive and the wharf was built farther out, with an approach 180 feet long and 40½ feet wide, and a T-head 373½ feet long and 50½ feet wide, all supported on piles. The depth along the sea-wall was 0; at the outer face of the dock it was from 12 to 14 feet, but this was dredged 26 feet before the piles were driven. The bottom was very hard, sand and gravel compacted in clay, with occasional bowlders. Piles were driven as deep as they would go, generally 10 to 15 feet. None of the piles were creosoted, the polluted water of the upper bay being free from teredo.

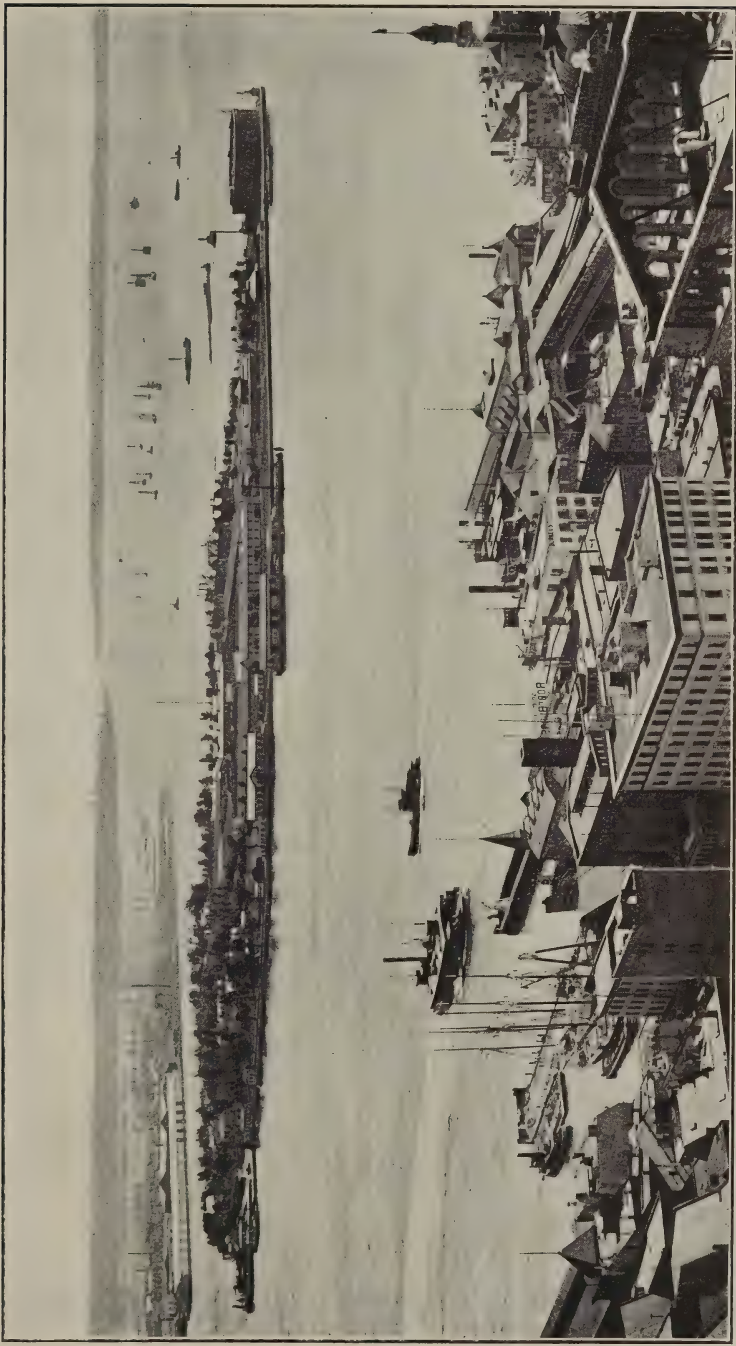


Fig. 2. General view of Governors Island from Manhattan Island, taken before work of extension began.

8. The work was done at unit prices. The entire cost of the contract was $26,622.05, being an average of $1.02 per square foot. It would cost at least one-third more at current prices of 1912.

9. Eight mooring posts, eight cleats, and minor additions made the cost of the completed wharf $27,200.90.

Details of Cost.

	Cost.	Per ct.
660 Y. P. bearing piles, 25 to 50 feet	$6,725.00	25.4
54 Y. P. bracing piles, 50 feet	648.00	2.4
123 W. O. fender piles, 50 to 56 feet	1,610.00	6.0
40 W. O. dolphin piles, 56 feet	640.00	2.4
392,976 feet B. M. Y. P. rangers, clamps, flooring, braces etc.	14,540.11	54.6
58,608 pounds bolts, spikes, chain, etc.	1,973.42	7.4
6,936 square feet tar paper	485.52	1.8
Total	$26,622.05	100

10. It was purposed to put a fine storage building on this wharf. Plans were drawn, to be revised by an architect in order to have a building of style and appearance suitable to its conspicuous position. Under plea of emergency the Post Quartermaster obtained permission to temporarily put up a shed on the wharf, which he subsequently enlarged to cover the entire floor, and the plan for a more sightly structure was side-tracked.

DREDGING IN FRONT OF SEA-WALL.

11. This was to make a suitable depth at the new wharf, and in order that the wharf piles should be driven below the dredged depth excavation along the face of the wharf was done before the piles were driven. It was expected that army transports would use the wharf and this was the controlling consideration in fixing the length of the T-head, as well as in deciding upon the depth to be made, 26 feet at mean low water.

12. Dredging was done under a contract which included removal of bowlders and everything else except ledge rock, at price of 78 cents per cubic yard. Work was begun November 22, 1901, and completed July 31, 1902, with removal of 70,550 cubic yards of material. An outcrop of ledge was uncovered and in 1903 was

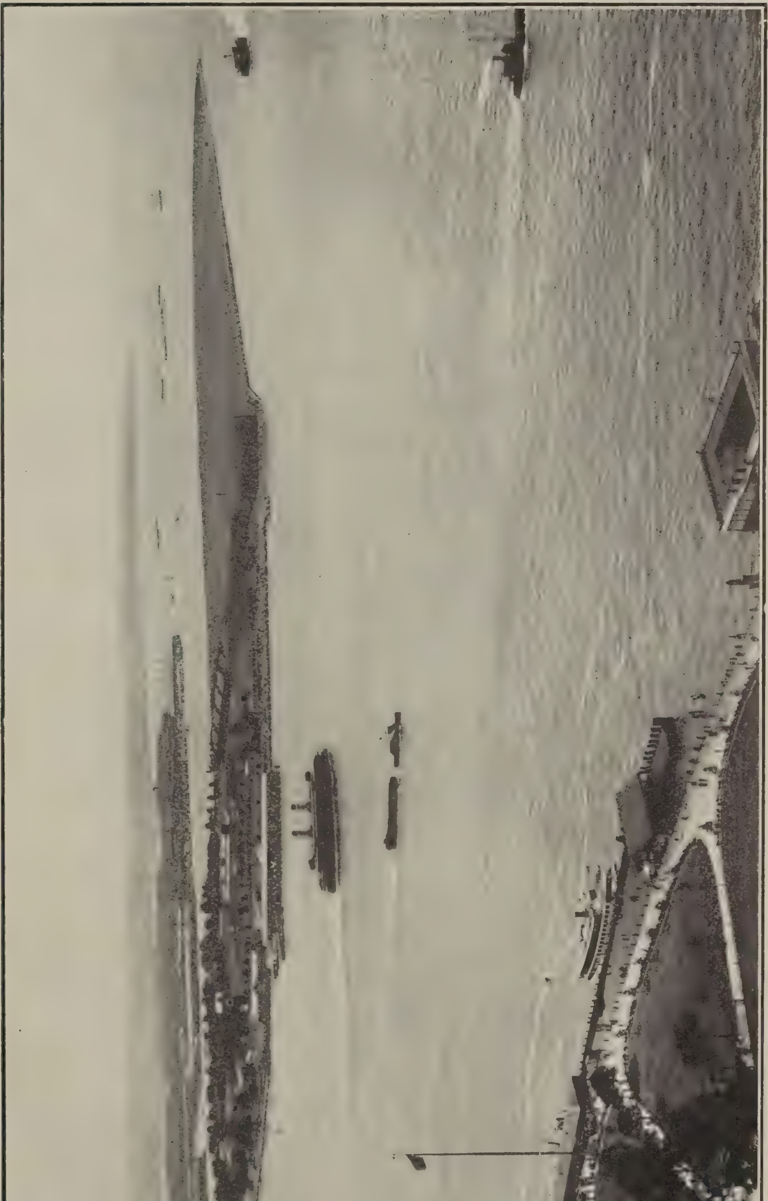


Fig. 3. General view of Governors Island from Manhattan Island, taken after extension was completed.

removed to the required depth. The total cost of this excavation was $56,790.00, from which $263.33 was deducted as cost of inspection during extension of contract.

13. The change in location of wharf and corresponding reduction of amount of dredging resulted in a saving, including inspection, of about $40,000.

14. The area dredged 26 feet deep extended 200 feet in each direction beyond the face of the wharf and then turned off at an angle of 30 degrees, to deep water.

15. The wharf and dredged basin have not, in fact, been used by large ships.

SEA-WALL INCLOSING THE ENLARGEMENT.

16. This was originally planned to be about 5,800 feet long, built of crib with timber superstructure at estimated cost of $125 per linear foot; total, $725,000.

17. Borings showed a generally soft bottom except close to the old island, and after some deliberation the conclusion was reached that a foundation of riprap sunk to a natural sustaining depth in the mud would be quite as secure as crib work, easier to repair if required, and much less expensive. At that time a riprap wall to retain sand filling had not been tried in this vicinity, if anywhere, and doubts were expressed as to whether the embankment would not run through the wall. The officer in charge was not unduly tied down to precedent, and with his approval, sanctioned by the Chief of Engineers, the design was changed to provide a riprap foundation with masonry wall on top. The plan was successful and has since been adopted, even to the extent of copying the specifications, by the New York Dock Department at Rikers Island and at the new Brooklyn Shore Drive revetment.

18. The foundation settled during construction an average of about 4 feet; it has settled somewhat since and in places may not yet have quite reached a permanent level. This is no more than would have occurred with crib work, and perhaps not as much.

19. The leakage through the wall was very small, roughly estimated at 500 yards. It occurred only where mud lay against the riprap, and there only while the bank of the fill was between low and high water and the mud was stirred up by ripples. It was enough to noticeably stain the water in the immediate vicinity, outside the wall. When the fill was built up to or above high water, the voids in the stone filled up permanently and the leakage ceased.

20. The wall was built of large and small stones mixed, so as to make it as compact and tight as practicable for stone placed under water.

21. Riprap foundation was begun in November, 1901, and finished in November, 1904, except at a gap 350 feet wide left at the outer end to admit scows bringing material for the embankment. The gap was filled in and the foundation finally completed January 31, 1911.

22. The foundation was planned with side slopes of 1 upon 1. For 2,200 feet on the Buttermilk Channel side and where exposure to waves was least, the top was 12 feet wide at 2 feet above low water. The rest had a top width of 15 feet, 3 feet above low water. The total amount of stone placed for this work was 404,115 tons (2,240 pounds). As the stone settled into the bottom additional riprap was put on the outer slope to the amount of 33,496 tons, making a total of 437,611 tons. The length of riprap is 7,207 feet, and the depths in which the riprap was placed ranged from 0 to 26 feet.

23. While laying the riprap an effort was made to record the amount actually placed in different sections of 200-foot length, so as to determine the amount of settlement in each section. This proved impracticable. The stone was measured by the barge load and when, as was usually the case, a barge discharged into the different sections, there was no way of estimating how much went to each. In two cases the amounts as recorded would indicate a negative settlement. By dividing the wall into two sections, one on the Buttermilk Channel side extending across the gap and 3,703 feet long, the other on the Hudson River side, 3,504 feet long, the inaccuracies of overlapping are reduced to a minimum. The Buttermilk Channel wall averaged 45.0 tons to the linear foot which (at 18 cubic feet to the ton) would build a wall to contract dimensions in water 20.1 feet deep. The average depth in this section was 16.6 feet, and the average settlement on top of the masonry wall to date is 0.6 foot, making the average sinking of riprap into the bottom (20.1—16.6+0.6) 4.1 feet.

24. The Hudson River wall averaged 61.5 tons, or 1,107 cubic feet to the linear foot, which would be the estimate for such a wall in water 23.6 feet deep. The average depth before work was 20.5 feet, and the average settlement on top of the masonry wall is 1.0 foot, indicating an average settlement of riprap (23.6—20.5+1.0) 4.1 feet.

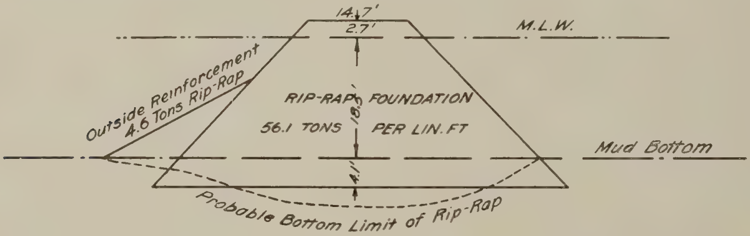
25. The exact agreement of these two is accidental. It would

seem that the Hudson River wall, with its greater weight, would sink deeper, and presumably it did, the exact slope of the sides as built being difficult to determine. But it is obvious that for this structure, or one under similar conditions, the original estimates of the amount of riprap required before it reaches a fixed level should be based upon depths about 4½ feet greater than actually observed depths.

26. Sketch below shows an average cross section of the riprap foundation for this sea wall.

27. The riprap for this work was purchased under three contracts at prices per ton of 2,240 pounds for stone delivered in place, 35 cents, 58 cents and 38 cents. The stone was obtained from New York City excavations. The construction of the subway at the time made it possible to get such stone in large quantity and at low prices.

28. The masonry wall is of granite on a concrete base laid in the top of the riprap. The wall has a coping course 3 feet wide laid at 10.4 feet above low water. It was built under three contracts, at prices of $18.75, $20.25 and $21.00 per linear foot. It has settled, with the riprap, an average of 0.8 foot, and at one point 2.4 feet. When it has reached a permanent level—presumably in two or three years—the coping course for nearly one-half its length should be lifted and a leveling course placed underneath.



29. Since the sea wall was built it has been run into by vessels three times under conditions, as far as known, which show inexcusable neglect on the part of navigators.

30. The entire cost of this sea wall and foundation, exclusive of inspection was

Riprap, 437,611 tons	$195,233.50
Masonry wall, 7,219 linear feet, including repair of damage by collisions	143,543.20
Total	$338,776.70

being an average cost of $47 per foot.

(Extension into and connection with old sea-walls make the length of masonry wall 12 feet greater than that of the riprap.)

31. The resultant saving on the orginal estimate of $725,000 for 5,800 linear feet of crib made it possible to increase the area of enlargement from 84½ acres to 103½ acres, and to pay for the filling at a cost greater than the estimates.

EMBANKMENT.

32. The original estimate provided for 4,000,000 cubic yards of sand filling, which it was estimated could be placed for 4 cents a yard. The amount was sufficient for 84½ acres, but the price was impossible. Material which could be dumped from scows could be had for nothing or even at a premium, but two-thirds of the entire amount had to be rehandled and the average cost of the coarse filling in place (exclusive of sum paid by the Comptroller of the Treasury and referred to later) was 8½ cents per yard.

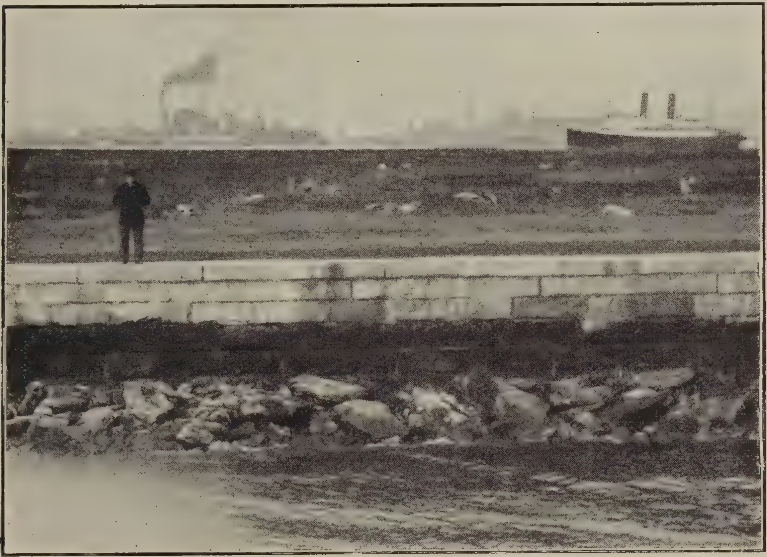


Fig. 4. Governors Island extension sea wall. Buttermilk Channel side. Looking Northwest; January 22, 1914. Top of wall covered with frozen spray.

33. Under the first contract an effort was made, by liberal conditions, to obtain prices approximating the estimates, and a contract was entered into for placing sand and hard material at 7.4 cents per yard and mud at 3.6 cents. This contract extended over a period of nearly four years, during which 1,566,431 yards of sand and 530,631 yards of mud were delivered. It

was brought into the inclosure and dumped from dump scows. At first, the contractors tried to put it in place with clam shell dredges, but failed because the dredges had not a long enough reach. Afterwards, they rehandled the material with a pump and then the delivery of mud had to be stopped, because it separated from the sand and was carried away to the bottom of the fill. These contractors did not meet the terms of their contract as to placing the material in the embankment, and payment was refused for the latter part of the work until it was done as contracted for. They succeeded, however, in convincing the Comptroller of the Treasury that they ought to be paid, and he paid them direct from the Treasury the sum of $72,708.70, against the protest of the District Engineer Officer, and the Chief of Engineers. His action increased the cost of the work by the amount stated.

34. Under subsequent contracts payment was made only for fill placed above mean low water, at price of 17 cents, 22.6 cents and 18 2-3 cents per cubic yard, the part below low water not to be paid for. The differences in price were mainly due to the differences in accessibility of points where the work was done. Part of this was put in place by pumping and part was taken from barges by derricks set up on the sea-wall, and was transferred to cars which carried it out on the embankment.

35. The whole amount placed in the embankment, reduced to place measure, was 4,787,748 cubic yards, and the cost was as follows:

4,639,433 cubic yards sand, mud, etc., at average cost (including amount paid by Comptroller), at 10.03 cents	$465,325.80
138,899 cubic yards surface earth, spread and graded, at 50 cents	69,499.50
9,416 cubic yards fertilizer, spread and harrowed in, at $3.50	32,956.00
Seeding, 79 acres, at $35.00	2,765.00
Total	$570,546.30

36. The surfacing, fertilizing, and seeding were confined to the area of 79 acres nearest the old island. The funds in hand did not suffice for the whole area.

37. This embankment was built up to the level of the sea-wall, with rising grade inward of 1 on 200, to provide surface drainage.

38. Soundings taken before work was begun show an average depth over the 103½ acres of 14.584 feet. Levels on the completed fill have an average height of 12.150 feet above low later. This makes the volume to be filled, after deducting 6,500 yards placed on

the old island and 110,500 yards occupied by the riprap and wall, 4,347,043 cubic yards.

39. The amount actually put in, reduced to place measure, was 4,763,674 cubic yards. A small amount of this, estimated at 500 cubic yards, leaked through the riprap. A much larger but wholly unknown amount, which may be guessed as 20,000 yards blew away into Buttermilk Channel on the slopes of the island. This would leave 4,743,174 yards in the fill, or 396,131 yards more than the estimate—about 9 per cent of the whole amount and enough to account for an average settlement of bottom of nearly 2½ feet. No degree of accuracy can be claimed for this greater than the accuracy of the assumption that the average ratio of this material measured in scows to a place measurement is 6 to 5.

40. Following is comparison of the original estimates with the work and cost as actually carried out:

Original Estimate.		Actual Construction.	
Repair to dock at Castle Williams.	$15,000.00	$2,850.00	Repair to dock.
		3,850.00	Dredging at dock.
Wharf along sea wall —250,000 cubic yards.	100,000.00	27,200.95	Dredging 26 feet at new wharf — 70,550 cubic yards.
Enlargement of island 84½ acres.			Enlargement of island— 103½ acres.
5,800 linear feet crib dike, at $125.	725,000.00	338,776.70	7,219 linear feet wall on riprap base.
4,000,000 cubic yards sand filling at 4 cents	160,000.00	570,546.30	4,787,748 cubic yards filling, fertilized and seeding, including Treasury payment of $72,708.70.
		10,624.39	Maintaining Light and Fog Bell.
		3,209.54	Intercepting sewers.
		85,668.95	Inspection, surveys, and supervision.
		425.74	Office building for inspector.
		96.75	Repair of pavement; grass seed.
		226.66	Balance unexpended, Oct. 24, 1912.
		$1,100,002.60	
		2.60	Less Receipt sale of blue prints.
Amount of estimate---	$1,100,000.00	$1,100,000.00	Amount appropriated.

41. The pile wharf has been in use for eight years. It was very substantially built and is now in good condition.

42. The enlargement consists of 103½ acres, built at a cost of about $10,300 per acre. It is nearly level, mostly seeded down to grass, and is ready for use. In no case, however, can this embankment, resting on several feet of compressed mud, be regarded as a safe bed for heavy masonry buildings or for large machine shops. All heavy structures should be supported on piling or other foundations of their own.

Flood Prevention*

BY

Maj. J. C. OAKES
Corps of Engineers; Member American Society of Civil Engineers

During the period of great floods last year, the Secretary of War directed the Chief of Engineers, U. S. Army, to appoint a Board of Officers to make a thorough inquiry and examination into existing conditions, and "report upon the most practicable and effective measures for prevention of damage by floods to works constructed for the improvement of navigation, of interference with interstate commerce, and of other disastrous results thereof."

As a member of the Board created in accordance with that order, it gives me great pleasure to be present with you and to have the privilege of addressing you on the subject of "Flood Prevention and Protection from the Point of View of the Federal Government."

I have listened with a great deal of pleasure to the very instructive discourse of Mr. Knowles on the subject of Floods and Conservation, and as our ideas may seem far apart and even in direct opposition, I wish to take this opportunity to affirm that I am not advocating one method of protection to the exclusion of any other, but wish to show that all methods should be used as circumstances dictate; and above all, I wish to emphasize the immensity of the problem of flood protection for a large river system like the Mississippi, or even one of its main tributaries, such as the Ohio.

I also desire to acknowledge my indebtedness for information to an unpublished report of the Board on River Floods.

Before discussing the Government's attitude toward this question, I desire to discuss the subject of floods and the methods of prevention now commonly under discussion.

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*Address delivered before the Indiana Sanitary and Water Supply Association, Indianapolis, Ind., February 26, 1914.

Floods are caused by excessive rainfall, quick melting of a thick blanket of snow, or a combination of the two, quick run-off, and channels inadequate to take care of the resulting flow of water. The run-off may be hastened by frozen ground, or a ground saturated by previous rainfall so that all of the precipitation escapes rapidly. The natural channel capacities may be and usually are reduced by artificial obstructions which prevent free and easy run-off.

Flood prevention measures must reduce precipitation, retard run-off, or increase capacity of the channels. I think that it is generally agreed that it is beyond the possibility of human ingenuity to control precipitation. The only method that has been seriously advanced is by forestation, and even for that method I am not aware that its advocates claim that forests decrease precipitation. It is certain that for all practical purposes the control of precipitation by forests or other means is at present impossible.

Flood prevention must deal, therefore, with the other causes of floods.

Run-off may be retarded by the retention of precipitation on or in the ground, or by the use of reservoirs. Several means of holding the precipitation where it falls have been proposed, such as deep plowing, contour plowing, and forestation. The term deep plowing is self-descriptive and the method is advocated not only for the purpose of retarding run-off, but also as a means of improving the yield of agricultural land. If all cultivated land could be plowed deep and the material well broken up, a considerable amount of precipitation would be retained by the soil. However, as can be readily seen, as a means of flood prevention, it is hardly within the control of either the Federal Government or the States. Furthermore, with a storm like that of last March and April, where in certain localities in Ohio over 11 inches of precipitation occurred, it is very doubtful if more than a very small portion could be held in the soil, even if plowed deep. Again, a large part of the country is uncultivated and covered by forests, hillsides and towns. This method, therefore, is very limited in its application and apparently impossible of control.

Contour plowing is a term applied to the method of plowing which creates ridges following the contours of the land and forms, as it were, terraces in such a manner that water will be held where it falls. This method, or perhaps a modification of it by the use of small dikes, is used extensively in foreign countries, such as Japan and the Philippines, where there is an excess of rain in one season to be followed later by a season of drouth. Under such climatic conditions, holding the water on the lands becomes necessary, else no crop can be raised.

In the eastern and middle western states these measures are not necessary for agicultural purposes, and while, if used extensively, they would retard run-off to some extent, they are impossible of control.

Both of these methods, therefore, seem to have advantages within certain limits, and would seem desirable, but they are not feasible means.

This brings us to forestation. This subject was treated at some length in the report of the National Waterways Commission, and the following is quoted from their report:

> It is generally admitted that forests exercise such reservoir characteristics and under favorable conditions to a sufficient extent to improve the regularity of stream flow. There is, however, a decided limit to the quantity of water which a forest cover can absorb. The capacity for absorption varies greatly under different conditions, depending upon the depth and character of the forest litter, as well as of the soil underneath, whether pervious or impervious, also upon the condition of the ground, whether frozen or not, upon the steepness of the slope, and numerous other factors. Where the forest litter is destroyed by forest fires, or is removed to prevent them, the absorptive capacity is thereby reduced.
>
> Various experiments have been made to ascertain the amount of water which different kinds of forest litter could absorb and hold. The results show that in general an amount equal to a precipitation of 0.16 of an inch can ordinarily be retained, while under favorable conditions the absorption of an amount equal to 0.24 of an inch or even more is possible. The soil beneath the humus may also be capable of some absorption. As soon as the saturation point is reached, additional rainfall must necessarily run off on the surface just as if the ground were deforested. This explains why forests are powerless to prevent floods, although, to the extent that they do absorb the precipitation, they may mitigate them.
>
> Effects of forests upon floods. Floods are caused primarily by a heavy and prolonged precipitation, amounting oftentimes to several inches within twenty-four hours. During the heavy rains which caused the disastrous floods in the Passaic Valley in October, 1903, 14 inches fell, according to records taken at New York and Newark. The worst floods usually occur in the spring when these

heavy rains fall upon a considerable accumulation of snow, which melts rapidly and augments the amount of water already precipitated. At this time the ground is more apt to be frozen or saturated and its capacity for absorption to that extent and impaired.

Forests retard the melting of snow in the spring and by allowing the water from this source to be absorbed, exercise a beneficial influence upon stream flow, but should heavy spring rains fall upon the snow thus preserved and cause it to melt within a few hours the effect of the forest is in such a case to aggravate rather than ameliorate flood conditions. It thus appears that under one set of conditions forests may exercise a beneficial influence upon stream flow and floods, while under another their influence will be harmful.

Assuming that the above is a fair statement of the effects of forests on stream flow, it will be noted that an amount of precipitation equal to 0.16 of an inch can ordinarily be retained, while under favorable conditions the absorption of an amount equal to 0.24 is possible. Applying the factor of 0.16 of an inch to the State of Ohio, and to the storms which created the flood of March and April, 1913, if the whole State of Ohio could be reforested and could retain 0.16 of an inch of rainfall, only 2 2-3 per cent of the total rainfall would have been retained by the storage effect of this forest. The present forest area of Ohio is about 9,000 square miles, or a little less than one-quarter of the State of Ohio. If we could change an additional 10,000 square miles of present cultivated land back into forest, this additional forest under the most favorable hypothesis would retain only two-thirds of 1 per cent of the rainfall of such a storm as that of March 23-27, 1913.

This subject was very thoroughly discussed in the Transactions of the American Society of Civil Engineers in connection with an article by Brigadier-General H. M. Chittenden, Corps of Engineers, U. S. Army, on the subject of "Forests and Reservoirs in their Relation to Streamflow, with particular reference to Navigable Rivers." As illustrating the bad influence that forests may have upon run-off, he states:

> In the first place, forests break the wind, prevent the formation of drifts and distribute the snow in an even blanket over the ground. * * *
>
> The water from the first melting of the snow blanket does not sink into the ground, but into itself. The forest shade thus holds the snow, which gradually becomes saturated from its own melting until the heat and warm rains of late spring and early summer arrive. * * *

> The result is that when the final melting begins the whole body of snow disappears very rapidly, rushing from every direction into the streams, swelling them to their limit and often causing disastrous freshets. * * *
>
> The delay in melting caused by the forest shade has simply operated to concentrate it into a shorter period and increase the intensity of the resulting freshet.

I believe that all of us will agree that the above statements are correct under certain conditions, and that by retarding the melting of the snow, forests have, on occasions, contributed to disastrous floods. Furthermore, even if it could be proven that forests exert on the whole a very beneficial effect, it is impracticable to convert fine agricultural land into forests. This country is certain to be more thickly settled than at present, greater crops will be needed for the support of the people and all tillable land will be ultimately used for the cultivation of crops until timber becomes so scarce that its value will pay the farmer to set aside a portion of his farm for its cultivation. Another objection to this method is that the formation of a humus sufficient to have its maximum effect in absorbing rainfall requires a long period, probably at least a century.

For these reasons it seems to me inexpedient to advocate reforestation as a means of prevention of floods.

The last mentioned and most feasible method of retarding run-off, is by the use of reservoirs. We have heard much on this subject within the last few years, and it has became a popular remedy for the prevention of floods.

If a certain amount of water flows downstream creating damage during its flow, it is apparent to anyone that if that water can be held in a reservoir and allowed to escape slowly, no damage would occur. Therefore, without understanding the immensity of the problem the ordinary man thinks he sees a remedy for floods and proceeds to become an advocate of what has come to be known as the reservoir method of flood prevention.

I desire to dwell on this subject at some length, for the purpose of showing that the problem is not as simple as stated above. There are without doubt many localities that may be protected by a reservoir or reservoirs. For instance, in the study of flood protection for the city of Columbus, O., the engineers were able to show that there were available sites immediately upstream from that city, which could be converted into holding reservoirs sufficient to take care of a flood similar to that of March and April,

1913. If such reservoirs had been in operation and had been controlled properly, releasing only sufficient water to fill the channel and not overflow the banks, no serious damage would have occurred in Columbus. It is also reported that the consulting engineers for the city of Dayton have shown that not only that town, but several others in the immediate vicinity, may be protected in like manner. The Pittsburgh Flood Commission has studied the subject in connection with flood protection for their city, and they have evolved a plan which appears to be ample to provide against future disastrous floods at Pittsburgh, if however, the control of the reservoirs is possible to obtain results in accordance with the plans.

When one comes, however, to consider the prevention of floods in a river system like that of the Mississippi, the problem becomes exceedingly difficult. In the first place, reservoir sites are not generally found close to the points where the damage will occur, and this is particularly true of the Mississippi.

Col. C. McD. Townsend, Corps of Engineers, U. S. Army, President of the Mississippi River Commission, in an address before the Drainage Congress in the spring of 1913, stated:

> To have retained the Mississippi flood of 1912 within its banks would have required a reservoir in the vicinity of Cairo, Ill., having an area of 7,000 square miles, slightly less than that of the State of New Jersey, and a depth of about 15 feet, assuming that the reservoir was empty when the river attained a bank-full stage. Cairo is the logical location for a reservoir to regulate the discharge of the Lower Mississippi. It will not only control the floods from the Ohio, but also the discharge from the Missouri and Upper Mississippi. But if the reservoirs be transferred from the mouths of the tributaries to the headwaters, their capacities must be largely increased.

It is not to be supposed that the people of Illinois and Missouri would be willing to have a portion of their territory as large as the State of New Jersey turned into a reservoir.

In this connection it should also be remembered that at the headwaters of the Mississippi there is the largest artificial system of reservoirs in the world, with a capacity of 93,000,000,000 cubic feet. These reservoirs have been successful in slightly increasing the low water discharge of the Mississippi River above St. Paul, and also in reducing floods in that portion of the river; but a hundred miles farther downstream it is impossible to detect their influence during either high or low water.

The Ohio River, in which we are more particularly interested, has a very large flood discharge. At Louisville, for instance, the maximum discharge is 790,000 c. f. s. At the mouth of the Ohio the estimated maximum discharge amounts to 1,500,000 c. f. s. Let us see what effect the system of reservoirs proposed for the protection of Pittsburgh would have had at Louisville during the flood of March-April, 1913. The Pittsburgh Flood Commission proposed the construction and operation of seventeen reservoirs whose total capacity is approximately 59,500,000,000 cubic feet. The amount of water flowing past Louisville during the day of maximum height was approximately 67,392,000,000 cubic feet. The proposed reservoir system, therefore, would have been more than filled by one day's flow at Louisville. If we assume that the dangerous flood height at Louisville is 54 feet, then, to have kept the river below that height during that flood, a storage capacity 7,300 square mile feet, equal to 200,000,000,000 cubic feet would have been required, or over three times the capacity of the proposed Pittsburg system.

If there had been a reservoir just above Louisville, with a capacity of 7,300 square mile feet, and if such reservoir had been empty when the flood stage of the Ohio River occurred, the Ohio River at Louisville could have been kept below the flood stage. But anyone can see that it would not be feasible to construct a reservoir of such capacity between Pittsburgh and Louisville because of the great value of the land, towns, improvements, etc., that would be submerged.

Another illustration may be taken from the Wabash River. The office of which I have charge had just completed the field work of a survey of this stream between Terre Haute and the mouth at the time of the 1913 flood. At Mt. Carmel, 95.7 miles from the mouth, discharge records had been kept and discharge curves had been constructed, and while no actual measurements were taken at the crest of this flood, assuming that the curves prolonged are correct above actual measurement points, we are able to arrive at an approximate value for the discharge of that stream at Mt. Carmel during the period of flood. To have reduced the flood height 1 foot during ten days would have required a reservoir capacity of 26,000,000,000 cubic feet, or a reservoir approximately 100 square miles in area, with an average depth of 10 feet. To have kept the Wabash River within its banks at Mt. Carmel between the date of March 25th and April 21st, would have required a storage capacity of 260,000,000,000 cubic feet, amounting to 9,300 square mile feet. This would have required a reservoir or reservoirs having an area of 930 square miles with water at average depth of 10 feet. It is apparent to anyone who knows the territory along the Wabash River that it would be impossible to find any such reservoir site in the vicinity of Mount Carmel, and even if found, the cost of such site would be prohibitive.

It is evident, therefore, that on the large rivers like the Mississippi and the Ohio, there will be few reservoir sites close to the main streams that can be used to control floods and that sites must be found on the tributaries and generally at their headwaters. This complicates the problem and makes large numbers of reservoirs of immense capacity.

Speaking of this point with reference to the Mississippi River, Colonel Townsend stated:

> When, on April 2, the gauge at Cairo attained a height of 54 feet, there was flowing down the Mississippi River at least 2,000,000 cubic feet of water per second. It requires about eleven days for a flood wave to be transmitted the 966 miles between Pittsburgh, Pa., and Cairo. On March 22 the Pittsburgh gauge read 5.3 feet, which is produced by a flow in the Ohio River at that locality of about 15,000 second-feet. In ten days a flood travels the 858 miles between St. Paul, Minn., and Cairo. On March 2 the reading of the St. Paul gauge was 0.5 foot, corresponding to a discharge of the Mississippi of about 2,500 second-feet. In eight days the effect of a flood at St. Joseph, Mo., is felt at Cairo. On March 25 the gauge at St. Joseph read —0.1 foot, representing a discharge of the Missouri River of about 17,000 second-feet. If a system of reservoirs had been constructed which would have prevented all flow from the Allegheny, the Monongahela, the Mississippi above St. Paul, and the Missouri above St. Joseph, it would have reduced the 2,000,000 second-feet discharged by the Mississippi River at Cairo on April 2 less than 35,000 second-feet.
>
> The water which passed Cairo on the 2d of April came principally from the White and Wabash and the lower tributaries of the Ohio, and after the water of these rivers started to subside the flood from Cincinnati, though increasing from 57 to 69 feet on the gauge, could increase flood heights at Cairo less than 1 foot. The flood of 30 feet at Pittsburgh on March 28 produced its effect on the Cairo gauge on April 8. It has prolonged the flood without increasing its height.

If reservoirs are to be located on the headwaters of the tributaries, then sufficient capacity must be provided on each of the tributaries to allow for its maximum flood. This capacity will be many times the capacity estimated from the discharge of the main stream, because floods are generally caused by the flow from a number of tributaries, but seldom from the flow of all the tributaries at their maximum stage. Thus each individual tributary must be treated and reservoirs must be so operated that they will be empty when needed and when full they must be emptied slowly so as to prevent the piling up of water in the main stream.

A marked defect of this system is the possibility that one storm may follow another so closely that at the time of the second the reservoirs will be full and not available for storage purposes.

Besides the points mentioned above, there enters the question of costs. Reservoir sites are, in general, extremely costly. The Pittsburgh Flood Commission estimated the cost of its proposed system at $21,000,000, but a Board of Engineers, U. S. Army, in reviewing the report found that land and property damage were underestimated by $13,000,000, so if their other estimates were correct, the cost would be $34,000,000. If a complete system were practicable for the Ohio River, some idea of its probable magnitude may be gained from the fact that the area of the basin of the Ohio Valley is 204,320 square miles, while the drainage area of the rivers above Pittsburgh just referred to is but 18,920 square miles, or 9 per cent of the whole. Assuming that the cost per square mile would be the same as that for the Pittsburgh system, the total cost of providing reservoirs for the Ohio River would be $378,000,000.00. It is probable, however, that these costs would be greater, for the territory in question above Pittsburgh is not nearly as valuable as in such States as Ohio, Indiana, and Illinois.

The advocates of reservoirs for flood prevention recognize the enormous cost of this method of protection for a large river like the Ohio, and to offset this very pertinent objection they claim that the water stored in reservoirs may be used to produce power which may be sold to the public, thereby reducing the cost of flood prevention, and may also be used to increase the low water flow of streams thereby improving navigation.

It is true that reservoirs may be used for flood prevention and the water held therein used for power, or for increasing the low water flow of a stream, but the full capacity of a reservoir may *not* be used for all three of these purposes at the same time. Reservoirs to be used for flood prevention must retain the water during the possibility of floods, but the instant that possibility passes the water must be allowed to escape as rapidly as possible without doing damage, in order that they may be empty at the time of the next possible flood. The use of reservoirs for increasing the flow of streams at low water stages is just the reverse of this. They must be kept full as long as possible and the water only allowed to escape when it is absolutely necessary to increase the low water flow. The use of reservoirs for power, on the other hand, requires a constant flow with a constant head to obtain the best results, and the more nearly these conditions are met the more efficient is the plant and the greater income obtainable from a given expenditure.

A little thought on this subject will convince a reasonable man that the three uses of reservoirs proposed by their advocates are incompatible one with the other, and in my opinion if an endeavor were made to use the same reservoirs for these three purposes it would not be long before the power interests would obtain control, and it would be practically impossible for a Government agent to empty a reservoir in anticipation of a flood when the power interests desired the reservoir to be kept full in order to provide uniform power for their plant.

In any case, it will be seen from the above that to prevent floods by the use of reservoirs will require a certain definite capacity; that if these reservoirs are to be used for any other purpose their capacity must be vastly increased, thereby increasing the costs of the system. For these reasons it is believed that it would be extremely inadvisable for the Government to attempt to provide reservoirs for flood prevention combined with other uses incompatible with that object.

The cost of any system of reservoirs sufficiently extensive to have a radical effect on Ohio River floods will be very great, but owing to the scarcity of reliable information no estimate of cost can be made at present. Before undertaking or even advocating such a system the subject should be thoroughly studied, all necessary information collected, and estimates submitted based on knowledge rather than guesses. The Board, of which I have the honor to be a member, has devoted nearly a year to the compilation of all available information with reference to the Ohio and Erie basins, and it is remarkable to find how little information there is upon which to base authoritative computations. Practically the only maps upon which reservoir sites can be located are those of the Geological Survey, and their sheets cover only 45 per cent of the Ohio River basin, exclusive of Cumberland and Tennessee rivers. No location surveys have been made except in very few cases; rainfall and run-off records are incomplete and discharge records of flood stages of the tributaries are almost nonexistent. Before the feasibility of protection by reservoirs in any particular case can be affirmed, available information must be supplemented by extensive, reliable data as to run-off, flood heights and discharges, available sites and costs.

The capacity of streams may be increased by the use of levees, dredging, or auxiliary channels.

With reference to levees it should not be necessary to discourse at length. This means of flood protection has been used for many hundreds of years. It is a means available for the immediate protection of sites or areas of varying size. Large areas of the Mississippi basin are protected by levees, as well as many towns on that and other rivers. New Orleans and Cairo are so protected. With this method the solution is simple, and the only important questions are to determine the size of the levees and the cost. An area may be made secure against any flood of similar height to those we have had in the past, or that may be expected in the future. The method is simple and direct and is the only method extensively used for protection in cases of large river systems. The levee system on the Mississippi has been in process of construction many years, and while it is true that breaks occur which cause vast damage, it is due to the fact that such levees have not been constructed to the height necessary for protection against the greatest floods. Where a community felt itself too poor to provide against the highest floods they have built their levees as high as their funds would allow, with the expectation and knowledge that when a higher flood came the levees would be topped. Shawneetown on the Ohio is an example of this policy. The Mississippi River Commission has elaborated a plan for levees which, if carried out, should make the Lower Mississippi valley absolutely safe against overflow.

Dredging may be used for increasing the capacity of channels where the increase required is very moderate, but a radical increase in the capacity of a large stream may not be accomplished by this method without the expenditure of enormous sums of money. A point often forgotten is that dredged material must be placed outside of the river channel if the dredging is to do any permanent good. This requires the purchase of lands upon which such material may be deposited, and increases the cost of actual dredging very materially.

No instance is known where a radical increase by dredging of the flood-carrying capacity of a river channel has been attempted on any large stream. The low water channels in streams like the Mississippi oftentimes are dredged to facilitate navigation, but it is believed that the limited application of this method should be apparent to all thoughtful minds. In this connection I am reminded of the remark frequently heard that it would advisable to bring the machinery from the Panama Canal to the United States to perform the necessary work of dredging the Mississippi and Ohio rivers. The machines formerly in use on the Panama Canal are adapted to the special conditions at Panama, which are very different indeed from the conditions to met on the Ohio and Mississippi rivers. Most of the excavating plant consists of steam shovels, locomotives, flat and dump cars, unloading machines, etc. The dredges in use were built for deep draught work and are wholly unsuited to river work. In any case, the dredges will be required for maintenance work on the canal and the other machines are not suitable for river dredging, and if brought to these rivers would be extremely inefficient.

Auxiliary channels have been suggested, both paralleling long stretches of streams and also to form cut-offs. The cost of providing additional channels for a stream like the Ohio or the Mississippi, of sufficient capacity to carry off the flood waters, is absolutely prohibitive. For the protection of a particular locality short auxiliary channels or cut-offs may be used, but these have the disadvantage that while they may benefit the locality in question by facilitating the run-off past that particular locality they pile the water up more rapidly below, thereby creating more damage at other points, as they necessarily cause steeper slopes, higher velocities, and greater erosion.

The methods of prevention of floods have been discussed at some length, and it must be realized that the subject is one of great extent and the problem in the case of large streams very difficult of solution.

We now come to the question of the prevention of damage by floods. The Board of which I am a member visited sixty-six different localities where the greatest amount of damage occurred as a result of last year's flood, and we found at almost every place visited that the damage was largely caused by artificial encroachments on the natural channels. For instance, many towns have grown up on the flood planes of the streams, occupying areas that have been overflowed from the beginning; people have entered the bottom lands and erected their structures with the knowledge that those lands were formed by silt deposited by flood waters; railroads have constructed earthen embankments across these bottoms, leaving only very narrow openings with wholly inadequate capacity for passing floods; city and county officials have built bridges with abutments projecting into the stream, with many piers of insufficient height, thus reducing the discharge area materially; individuals have dumped materials over the banks to increase the area of their property for business purposes. These structures and encroachments have reduced the capacity of the streams, have formed partial dams which raise the water above previous levels and then by the breaking of an embankment or the washing out of a bridge the water held back has rushed downstream under increased head and velocity, destroying everything in its path. In one report just submitted to the Secretary of War, numerous quotations are made from the various reports of committees of the Flood Board who visited the cities damaged by the late floods, giving examples of the contraction of the waterways, encroachments on the channels and the resulting damage. Aside from the damage done by the inundation of property, which, while serious, was not destructive, almost all of the damage at the points visited was caused by increased velocities of current due to the backing up of the water, by embankments, bridges, and other structures, the subsequent breaking of these partial dams and the rush of the released waters under increased heads and velocities.

The measures to be taken to prevent such damage are: wherever possible, to remove structures from the flood planes and river bottoms, or to elevate such structures above possible high water; to protect by levees valuable property which it is impossible to remove; to prevent the construction of heavy earthen embankments across flood planes by railroads or counties; to increase the capacity of channels by removing encroachments thereon in the shape of bridges, buildings, etc., and to remove all artificial and natural filling or deposits.

The work of the National Government along this line up to the present time has been limited. The principal work has been the construction of the levees on the Mississippi River. No other extensive work has been carried on for flood protection or flood prevention alone, although many of the works for improvement of navigation have tended to improve conditions with reference to floods. At the time of the great flood of last year the question arose as to the powers and duties of the General Government, and while it is probable that the power of the Government is sufficiently extensive to enable vast works to be carried on, there are at the present time no laws authorizing such works, unless they can be combined with works for the improvement of navigation.

As is well known, the National Government derives its authority for its various activities from the provisions of the constitution of the United States. It is a principle in the interpretation of the constitution that all rights are reserved to the States except those which are specifically and clearly given to the National Government, but once it is determined that the right obtains, it is possessed to its fullest extent, is superior to State rights, and is paramount even to the minutest details. Among the powers given to Congress by the constitution is: ''To regulate commerce with foreign nations and among the several States, and with the Indian tribes;'' and ''To establish post offices and post roads.'' Under the former of these provisions the Government has assumed control of navigable waterways and regulates navigation. In so far as floods interfere with navigation there is no question as to the right of Congress to pass laws for the control of such floods or the prevention of damage which may affect navigation. It matters not whether the laws have for their purpose the lowering of flood heights or the prevention of the wrecking of bridges, boats, etc., or the deposit of material washed from the upper parts of the stream into the lower and navigable portions. This power has been exercised in the past through the Engineer Department of the Army in charge of river and harbor districts, but has been limited in general to those stretches of the stream that are actually navigable. At the present time we are regulating the heights and widths of bridges, preventing deposit of material over the banks of the streams, or placing obstructions in the stream, etc., and on special occasions where it has been shown that material deposited in the stream above the navigable sections has been washed downstream, affecting navigation, the Federal Government has interfered and prevented such deposit. In general, however, its jurisdiction has been confined to the navigable portions of the streams. It would seem perfectly possible and within the powers of Congress derived from the constitution to authorize the extension of jurisdiction to all portions of navigable streams, whether actually navigable or not.

Furthermore, Congress in its power to establish post offices and post roads must naturally have the power to protect such roads, and to make regulations regarding them. As almost all the roads are used for carrying the mails, apparently Congress has the power to control the construction of bridges over nearly all streams, and also to prevent encroachments thereon, on the grounds that such roads are used as post roads and must be so constructed and so protected as to be without danger of obstruction or interruption due to floods.

It would seem, therefore, that Congress has in the two provisions of the constitution quoted above, ample power to control these matters and to take such action as may be deemed wise for such control. At the present time, however, the executive departments whose powers are definitely determined by law, have no control over streams unless they are navigable, and no control over the action of individuals, corporations or communities to prevent the obstruction of such streams, unless it can be definitely shown that such obstructions do interfere with navigation; and as soon as one of the departments attempts to exercise its power, unless the case is simple, objection is made and suit entered in the courts to determine whether under the laws that department has the right to demand correction or not.

It would seem that the measure most needed at the present time is an act definitely authorizing some department of the Government to prevent the encroachments on the streams, and if the Federal Government does not take up this question, it is within the power of the States to do so, and some measure or measures should be taken in each of the States to enable some department of their Government to control such matters.

There are numerous cases where the people of the community have recognized the great danger involved in the construction of a bridge for instance, and where protests have been made but without avail, because of the lack of laws under which any authority could act with hope of successful enforcement. It is a remarkable fact that in one of the towns of Indiana certain county commissioners are constructing bridges across a stream in direct opposition to a large proportion of the citizens of the town, the latter feeling confident that the bridges in question will cause great damage in the case of another flood, yet these citizens have been unable to find any power that would enable them to prevent the construction of such bridges.

If the Congress of the United States should take up this matter and should extend its jurisdiction to the headwaters of all tributaries of navigable streams, it would be possible for the agents of the Federal Government to determine whether or not proposed structures are dangerous to life and property during floods, and to require reasonable and safe construction. In the meantime the Board of Officers, of which I am a member, is studying all conditions affecting flood protection of the Ohio River basin, and has collected practically all of the information available. It has recently recommended in its report that an appropriation be made for carrying on this work and for making surveys and plans for definite improvements of localities and streams.

The Board feels that the problem of prevention of floods in the Ohio River basin is an immense one, whose difficulties are little understood by the mass of the people. A great deal of information is being disseminated, whose most remarkable quality is the lack of substantiation by definite facts. Newspaper and magazine articles are describing and advocating measures without knowledge of what they will ultimately mean to the people, and we feel that the first duty of the Board is to obtain definite and precise information on all these subjects, so that the people may know what can be done and what it will cost. We are not opposed to any method that will give relief, and as I have shown in the above discussion, there are many methods and measures that may be of assistance. It is probable that when the matter is sufficiently studied it will be found that all the methods described above may be used to advantage, and that each locality and each stream is a problem by itself, whose solution depends on local conditions and can only be determined when adequate knowledge is obtained.

An Ice Cofferdam

BY

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Some years ago the writer conceived the idea of using ice as a cofferdam in connection with the construction of the foundation for a small light in shallow water in Lake Memphremagog, but the time was too limited to effect the freezing. This winter he was able to make a practical application.

The United States dredge *Warroad* was repaired at Kenora, Ontario (Lake of the Woods) in 1912. After being put in the water, a leak showed on one side about 3 feet below water line. It was not bad at the time; the dredge was needed for work; and the leak was allowed to go. On the laying up of the dredge for the winter of 1913-1914, it was decided to try the ice cofferdam method to repair the leak, which was giving considerable trouble. Owing to the possible necessity of replacing an entire plank, the work was done on a much larger scale than proved to be necessary. On January 25th ice was 18 inches thick in Warroad Harbor. A trench was made 20 feet long, 3 feet wide and 12 inches deep alongside the dredge. Thereafter each day, when the thermometer had been below zero the night before, 1 inch of ice was cut out of the bottom of the excavation. Days when the thermometer was not higher than +15 degrees during the entire day, there were taken out 1½ inches. After each day's work a small hole was bored to a depth of 5 inches, and dry wooden plugs kept near to plug the holes in case the bit broke through, but it never did. The rate of cutting and the means of insuring a thickness of 5 inches in the bottom of the trench were determined by the custodian of the dredge, as he had no instructions except to get down to the leak. It is probable that he might have gone down somewhat more rapidly, but he was present every day in care of the dredge and there was no occasion to hurry. Parties harvesting ice at that time found that their ponds, left open at night, were frozen about

2 inches during the coldest nights. During the operation, the maximum daily temperatures ranged from +30 degrees to —15 degrees and the minimum from +6 degrees to —47 degrees. Only once was the minimum above zero, and the maxmium was below zero for five consecutive days.

On February 24th—exactly thirty days—there was a trench 20 feet long, 3 feet wide, and 34 inches deep, with 6 inches of ice in the bottom. The thickness of ice in the vicinity was 24 inches. So we had gone down 10 inches below the bottom of normal ice; we still had 6 inches under us; and had uncovered the leak 34 inches below water line.

The repairs amounted to nothing more than cleaning out a small split in a plank and caulking it.

Book Reviews

TECHNIQUE OF MODERN TACTICS, by Majors Bond and McDonough, U. S. Corps of Engineers. 350 pages. Cloth. 16 maps and figures. For sale by the U. S. Cavalry Association, Fort Leavenworth, Kansas. Price, $2.65, postpaid.*

This book merits the immediate recognition of all students of the Military Art, as a distinct advance on any existing work on applied tactics. It contains, briefly and concisely stated, the essentials for correct solution of the important problems included in the course in Military Art at the Service Schools at Fort Leavenworth, but more important still to the Service at large, it has brought together a large amount of information from a number of different sources, which will be of immense value to every officer in the field, whether at maneuvers or in active campaign. If only one book besides the Field Service Regulations could be carried into the field, this one should be chosen.

Every officer recognizes the necessity of conciseness in military books, a quality that this work carries almost to an extreme, so much so that ''a's'' and ''the's'' are at times omitted where clearness would dictate their retention. An example of this excessive brevity is in the following sentences: ''He sends word to (the) battery to form and prepare for action gives stations of fractions and routes thereto and directs them to proceed, telephone detail to report at B. C. station,'' evidently meaning ''*orders the* telephone detail, etc.'' Another instance is on page 116, ''When the commander rides forward, leaving command to follow . . . '' meaning, evidently, ''leaving *the* command (battery) to follow'' rather than ''leaving orders (command) to follow.''

The writers secure a forcible style by the use of short, strong, clear-cut sentences for each idea, rather than a long rambling style so common among writers.

The tactics taught is sound throughout and, due weight is given to the rôles of each of the three major arms (infantry, cavalry and artillery), a result not always attained by writers of infantry, cavalry, or artillery because of their more intimate association with their own branch, due to which they naturally throw too much emphasis on the functions of their own arm.

A logical course in tactics would indicate the study, first, of the ''Technique of Tactics'' with the Field Service Regulations and Drill Regulations of the various arms as reference books, previous to taking up the corresponding problems contained in ''Problems in Minor Tactics,'' to be followed finally by those found in Hanna's ''Tactical Principles and Problems'' on the same subjects.

The Technique of Modern Tactics is the culmination of the advance made in the study of applied tactics in our army during the past ten years, previous to which time we were depending almost entirely on Griepenkerl for all applicatory problems and methods as related to tactics.

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*See reviews of this work in the March-April, 1914, PROFESSIONAL MEMOIRS.—ED.

The Corps of Engineers owes a distinct debt to the authors for the success with which they have handled this subject, concerning which engineers are often supposed by our brothers of the line to be entirely lacking in information. It is needless to say we do not agree with this view, recently expressed in the *Infantry Journal,* nor do the facts of history bear out their contention.—C. O. S.

THE CONTROL OF WATER AS APPLIED TO IRRIGATION, POWER, AND TOWN-WATER SUPPLY PURPOSES, by Philip A. Morley Parker, A.M.I.C.E., Am.Soc.C.E., M.D.I.V., B.A. (Cantab.), B.C.E. (Melbourne). Cloth, 6 by 9 inches. Published by D. Van Nostrand Company, $5.00 net.

The author, who is apparently an Englishman, states in his preface that the book is not a text-book but rather a manual for engineers, and is the result of notes and formulæ accumulated in some eighteen years of professional work. The book has one thousand fifty-five pages. The print is, unfortunately, rather fine. The paper is quite thin, however, so that the book is not bulky or heavy. It contains a vast amount of information, with many formulæ and practical tables. It treats the theory of the different subjects quite fully and, in addition, gives much of the information that is ordinarily found in hand-books. The author very frequently gives references to the sources of his authority for particular values or statements which is of great advantage. It is interesting that these authorities are not limited to one or two countries but cover a big field. He seems very conversant with American literature on the subject, especially as presented in the Proceedings of the American Society of Civil Engineers. The chapter headings include the general theory of hydraulics; gauging of streams and rivers; gauging by weirs; discharge by orifices; collection of water and flood discharge; dams and reservoirs; pipes; open channels; purification of water; town water supply; irrigation; movable dams; hydraulic machinery; concrete, iron work, and other allied hydraulic construction. All of these subjects are treated quite fully with the exception of movable dams, which is the shortest chapter in the book. About half of the chapter is devoted to bear-trap dams, and it contains Powell and Chittenden's well-known analysis of the bear-trap. The chapters which would attract most of the engineers in the Engineer Department are those on the Gauging of Streams and Rivers, Open Channels, Dams and Reservoirs and Flood Discharge. Under Gauging the author presents quite a full discussion of the subject including meters, pilot tubes, gauging by chemical methods, influence of a tributary, methods in rivers with shifting beds, etc. This chapter should be considered in connection with the one on Open Channels which discusses, among other things, variable flow in open channels with latest data on transport of materials, silt and scouring velocities. The chapter on flood discharge is of more interest in connection with small streams than the larger navigable ones. In connection with dams is an interesting discussion of the stability of an impermeable dam and cut-off wall on a permeable foundation. At the beginning of each chapter is a sort of table of contents and frequently a summary of the equations and formulas, with a list of symbols used. The book will make a very valuable addition to any hydraulic library.—Ed.

Floods and Levees of the Mississippi River. By Benjamin G. Humphreys, Member of Congress from Mississippi. Cloth, 7 by 10 inches; 350 pages. Memphis, Tenn., Mississippi River Levee Association.

This book was written with a view to presenting to Mr. Humphreys' colleagues in the House of Representatives such data as would enable them to properly understand the problem when the subject of a speedily completion of the levee system is brought before them. It contains, however, much information of interest to the Government engineer. The subdivisions of the book are headed—

The Proposed Legislation.
Endorsements of Statesmen, Past and Present.
History of the Levee System.
The Long Fight for Federal Aid.
Levees Under the Mississippi River Commission.
Are Levees in the Interest of Interstate Commerce?
The Mississippi River and the Panama Canal.
The Constitutional Questions Involved.

Almost two-thirds of the book is appendices, as follows:

- Appendix A—
  - Memphis Address of Col. C. McD. Townsend.—Scientific American Editorial.
- Appendix B—
  - St. Louis Address of Col. C. McD. Townsend.
- Appendix C—
  - Hearings, 1910.—Statement of Judge R. S. Taylor.
- Appendix D—
  - Hearings, 1910.—Statements of Mr. S. Waters Fox and Mr. H. G. Wilson.
- Appendix E—
  - Hearings, 1890.—Statements of Gen. Cyrus B. Comstock, Col. Charles H. Suter, Capt. Smith S. Leach, and Capt. Dan. C. Kingman.—Discussion of Levees by American Society of Civil Engineers, 1903.
- Appendix F—
  - Hearings, 1904.—Statements of John M. Parker, Charles S. Fairchild, etc.

The book contains no new material, but has collected in a convenient form information sometimes difficult to get.—Ed.

Editorial Note

Students' Summer Military Camps

Attention is called to the military camps of instruction for students of educational institutions which will be conducted by the War Department during the coming summer. Camps will be held at Asheville, N. C., Burlington, Vt., and Ludington, Mich., from July 6th to August 7th, and at Monterey, Cal., from June 26th to July 31st. Two such camps were held last summer and seemed to be very much enjoyed and appreciated by the students who attended them. These camps are of great value in giving a short military training and also give the physical benefits naturally derived from the active healthful outdoor life of the encampment. The privilege of attending is extended generally to students of educational institutions, colleges, etc., and each student who elects to attend must do so for five weeks. The cost of attending these camps is very low. Subsistence for the entire five weeks is furnished by the Government for $17.50. Certain uniform is required and if the student does not possess any of it the cost thereof will be from $5.00 to $10.00, depending on quality selected. The only other costs will be transportation to and from the encampment, which each student must pay for himself. Cots, blankets, cooking outfits, etc., etc., are furnished by the Government. Even if the student had no special desire to benefit himself, this would seem a very easy and inexpensive way of getting a pleasant summer vacation and the benefit would be incidental as far as he was concerned. It is not supposed that many engineers, etc., in the Engineer Department will be eligible to attend these camps, but some of them will have friends and relatives who are eligible. It is recommended that any one interested in the matter write to Capt. R. O. Van Horn, General Staff, U. S. Army, Office Chief of Staff, Washington, D. C., who has been placed by the War Department in charge of the organization of these camps.

Erratum

In the article on ''Modes of Gauging Flow of Water,'' by Col. H. L. Abbot, which appeared in Volume I of the PROFESSIONAL MEMOIRS on page 319, ninth line from bottom: for the figures 0.96 and 0.98 read their reciprocals, 1.04 and 1.02.

PROFESSIONAL MEMOIRS

Corps of Engineers, United States Army, and Engineer Department at Large

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Maj. FREDERICK W. ALTSTAETTER, *Editor.* Lieut. EARL J. ATKISSON, *Business Manager.*

VOL. VI. JULY-AUGUST, 1914. NO. 28

Contents

(*Illustrations in each article are shown by italics.*)

Page.

1. MILITARY SURVEY OF OAHU 445-461
   By Lieut. F. S. Besson, Corps of Engineers.
   DISCUSSION 462-488
   By Capt. Warren T. Hannum, Majs. McDonough and Bond, Maj. C. O. Sherrill, Capt. Frederick B. Downing, and Lieut. F. S. Besson.
   Shore end of a ridge near east coast of Oahu Island 447
   Kalihiwaa Falls, Oahu Island 453
   View near east coast, Oahu Island 459
   General Map of Oahu 460
   Konahuanui, highest peak in the Koolau Mountains 467
2. MAP MAKING IN CONNECTION WITH LAND DEFFENSE FOR SEACOAST FORTIFICATIONS AND SEACOAST CITIES 489-503
   By Capt. Lewis H. Watkins, Corps of Engineers.
3. REVERSED PARKER BEAR-TRAPS, DAM No. 13, OHIO RIVER 504-525
   By Maj. F. W. Altstaetter, Corps of Engineers; M. Am. Soc. C. E.
   DISCUSSION .... 526-536.
   By Maj. H. Burgess, Corps of Engineers; M. Am. Soc. C. E.; and Mr. F. B. Duis, Assistant Engineer; M. Am. Soc. C. E.
   General view of Lock and Dam No. 11, Ohio River 505
   Cross section showing a design for the standard two-leaf bear-trap 509
   Cross section of two-leaf bear-trap 511
   Standard lower leaf under construction, showing main girders in place. 514
   Standard lower leaf under construction 515
   Standard trap under construction 516
   Showing cross section of large Reversed Parker Bear-Trap 519
   General view of Lock and Dam No. 13, Ohio River 521
   Part of the Z-leaf, large Parker Bear-Trap, after removal 523
   Reinforcing girder attached to upper leaf, large Parker Trap 525
   Upper leaf small Parker trap 531
   Reversed Parker trap at Colbert Shoals Canal 533
4. MAJ. GEN. MONTGOMERY CUNNINGHAM MEIGS (see frontispiece) ... 537-538
   By First Lieut. B. C. Dunn, Corps of Engineers.
5. THE WORK OF THE ARMY IN THE CONSTRUCTION AND MAINTENANCE OF ROADS 539-548
6. DAMAGE TO LINING OF FILLING TUNNEL, POE LOCK, ST. MARYS FALLS CANAL 549-552
   By Lieut. Col. Mason M. Patrick, Corps of Engineers; M. Am. Soc. C. E.
   Filling tunnel at Poe Lock, St. Marys Falls Canal 550
   St. Marys Falls Canal, Poe Lock; damage to north filling culvert 551
7. REPAIRING LEAKS IN AN 8-INCH WATER MAIN 40 FEET UNDER WATER IN GALVESTON HARBOR, TEXAS 553-559
   By Mr. N. T. Blackburn, Junior Engineer.
8. THE TEREDO IN FRESH WATER 560-561
   By Mr. R. G. McGlone, Junior Mechanical Engineer.
   Form used in repairing water main 554-555
   Method of placing form 557
   Form placed 558
   Pier roller fastened to upper leaf and plates set in pier to form track .. 529

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MAJ. GEN. MONTGOMERY CUNNINGHAM MEIGS
1816-1892
CADET, U. S. M. A., 1832-1836
LIEUTENANT AND CAPTAIN OF ENGINEERS, 1837-1861
QUARTERMASTER-GENERAL, U. S. ARMY, 1861-1882

SEE PAGE 537

Military Survey of Oahu*

BY

Lieut. F. S. BESSON
Corps of Engineers

INTRODUCTION.

The National Land Defense Board first actively took up the question of the land defense of Oahu early in 1908. In July of that year Major (now Lieutenant-Colonel) Haan, C. A. C., submitted a report to the Board. In this report he recommended that a company of Engineers be sent to Honolulu to make the necessary surveys along the lines described in his report.

Accordingly, Company A and Headquarters 1st Battalion of Engineers proceeded to Honolulu in the following November. After spending some time in establishing camp, on the military reservation afterwards called Ft. De Russy, field parties were sent out in December, 1908. The project at that time required the survey of several defensive lines and redoubt sites. The following officers of the command took active part in the field work: Second Lieut. C. L. Hall, Second Lieut. R. S. A. Dougherty, First Lieut. R. T. Ward, who was in command of the company, and First Lieut. C. S. Ridley, all of the Corps of Engineers. Major Winslow, the District Engineer Officer, had general supervision of the work. Among the enlisted men doing the surveying work were Sergeants Meyers and Dougherty and Corporals Morrison and Stam.

In May, 1909, Company A, First Battalion of Engineers, was relieved by Company G, Second Battalion of Engineers. Major Winslow remained as District Engineer Officer, and Lieutenant Ward joined G Company. The following officers came over with the troops: Capt. A. B. Putnam, C. E., Lieut. J. A. O'Connor, and Lieut. L. H. Watkins. Lieutenant Cunningham, of the Fifth Cavalry, was detailed to help with the survey for a few months. By this time, the surveying required by Major Haan's project was practically complete. The information obtained by the survey regarding the practicability of passing the mountain ranges, and further studies of the probable tactical situation, indicated the necessity of revising the project. It was decided that the final defensive line would not be chosen until after an instrumental survey had been made of the entire island. A complete topographical survey of the island was therefore ordered.

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*The military map of Oahu is not available for publication. A general map of the Island of Oahu will be found opposite page 460.

The principal surveyors and draftsmen among the enlisted men of Co. G were Sergeants Meyers, Dudzik, O'Donnel, Ginsburg, Emerson, Gartz, and Borger, and Corporals Stam, Huchberger, and Correthers.

The work was carried on by Company G until March, 1912, at which time it was relieved by Company I, Third Battalion of Engineers, which company carried the field work to completion in June, 1913. Major Wooten succeeded Major Winslow as District Engineer Officer, while the officers of Company I, carrying on the survey have been Capt. W. T. Hannum, C. E., First Lieut. C. C. Gee, C. E., First Lieut. J. R. D. Matheson, C. E., and First Lieut. F. S. Besson, C. E. Among the enlisted surveyors have been Sergeants Abshire, Aegans, and Gillies, and Corporals Starkey, Cosgrove and Stirling. In the drafting room have been Corporals Beam, Coleman and Cleland and Private Peters.

The military map of Oahu has been the chief duty of the companies and has involved a great deal of work, just how much it would be impossible to compute. Altogether, it has taken four and a half years, but during this time the companies have performed many of the regular military and garrison duties as well as various special duties assigned by Department Headquarters.

The field work has been carried out with a thoroughness that would probably not have been attempted by any other department of the Government. Long trails through the tropical jungle and over precipitous peaks have been cut in order to traverse every part of the island. Surveying parties have been established in subcamps in the mountains and supplied with food, and sometimes water, packed on the backs of men, from the end of the pack mule trails. On some of the mountain ridges work has been particularly difficult on account of rain or mist. In one sub-camp the surveyors were able to work but three days of one month, meanwhile expecting the atmosphere to clear away at any moment.

PROJECTION OF THE MAP.

Oahu is situated entirely between meridians 158° 15′ W. and

157° 40′ W. It lies wholly between parallels 21° 15′ N. and 21° 45′ N. The map is constructed on a polyconic projection, based upon Clarke's reference spheroid of 1866, considering the island as one sheet. The island is small, therefore the projection gives an approximation of great accuracy, the proportionality of the area being almost exact.

Many maps of special areas have been made by the Engineer troops, stationed on Oahu, on the scale of 1-6000 and 1-9000. Maps have also been made of the military reservations. Much work has been done and is still being done, on the scale of 100 feet to the inch and 5-foot contour intervals. The so-called "military map of Oahu"—that is, of the entire island, is 1500 feet to the inch with 20-foot contour intervals. This map is cut up into fifteen quadrangles of a size convenient for handling, and indexed from I to XV. Each sheet is 31.68 by 28.16 inches and covers an area of 72 square miles, 9 miles north and south by 8 miles east and west. A complete map of the island may be obtained by joining the sheets.

Fig. 1. Shore end of a ridge near east coast of Oahu Island.

The center of coordinates is taken at longitude 158° and latitude 21° 30′. The method used to plot the parallels and meridians is described in the various text-books (see Military Topography, Department of Drawing, U. S. M. A.) and extensive tables simplifying the work may be obtained from the Engineer Department or the survey departments of the Government. The parallels and meridians are practically parallel to the sides of the rectangular sheets. The convergence increases rapidly with increase of distance from the center of coordinates, but on this scale is hardly noticeable, even at the extreme edges of the island. On no sheet does the framework of parallels and meridians vary from being parallel to the rectangular sides of the sheets by more than approximately one-twentieth of an inch.

TRIGONOMETRIC CONTROL.

The survey is based on data obtained from the Territorial Government's primary triangulation, made about thirty years ago. The work was accurately done and permits the points to be plotted, with required precision, to the scale 1-18000. After adopting a projection and completing the triangulation, and before the computation of latitudes, longitudes, and azimuths can be made, it is necessary, in a survey such as this, to adopt a geodetic datum. That is, the position, found astronomically, of a specified station, must be adopted as a standard, together with an adopted geodetic azimuth of a line from that station. The surveys of the United States, from Maine to California, are based on an adopted United States Standard Datum. Similarly, the surveys of a detached island should be based on but one geodetic datum. From the geodetic datum, with the triangulation data, the longitude and latitude of the several stations, and the forward and back azimuths of the sides, are computed by formulæ, given in the standard text-books, for geodetic coordinates or positions. The Coast and Geodetic Survey has lately issued a new edition of formulæ and tables facilitating the computation.

After computing the above-mentioned geodetic positions, giving the coordinates of the stations in degrees, minutes, and seconds of arc, it is necessary to plot the points on the projection. The tables that were used in constructing the projection are again used and the points plotted as differentials of longitude and latitude. Thus we have the points located by the their coordinates X and Y, in inches, referred to the center of coordinates, and making due allowance for the convergence of the meridians and curvature of the parallels.

The traverses are controlled by adjustment on triangulation and sub-triangulation stations, and determining, by trigonometric methods, the positions of actual points. The amount and character of the control is governed by the judgment of the officer in charge of the detachment. For the most accurate results, an adjusted quadrilateral is established on the main triangulation as a base, or upon parts of other adjusted quadrilaterals. When less extensive control is needed, an adjusted triangle or the three-point problem is used.

The correctness of the map is dependent upon the number and accuracy of points mathematically located. The proper relation should be determined between the number of points located, the scale and purpose of the map, and the character of the country.

Fig. 2. Picture taken at an elevation of 2,000 feet above sea on the Kaluanui stream, shows the kind of country mapped.

ANGLES.

The transit is used to measure all horizontal and vertical angles necessary for traverse control and obtaining topography. For important horizontal angles, the method of repetition is used. For important vertical angulation a direct instrumental observation is taken, then a reading on the instrument reversed. The mean gives the angle with sufficient accuracy. The gradienter attachment, used as an adjunct to the vertical circle may, perhaps, add to the accuracy.

TOPOGRAPHY.

The topography is obtained by means of the transit and stadia, in conjunction with a field sketching table. The entire area to be mapped is covered by a system of irregular traverses, picking out the ridges and valleys and connecting the main points of the terrain.

A field party consists of a sketcher, or topographer, who is usually in charge of the party, a transit man, computer, recorder, and as many rodmen and trail cutters as the chief of the party can keep busy. In running the traverse, the transit man must make a study of the topography, so that he is able to run the line and pick out side-shot positions intelligently, in order that the topographer may give his full attention to sketching. It is not difficult to develop a transit man, but the same may not be said of the sketcher. Contours indicate precision and should justly be accurate. Since it is impracticable to establish every point on a contour, the work of the topographer is not only mathematical and mechanical, but is to a certain extent artistic, depending upon individual skill and natural talent, improved by long practice and experience in the field. For these reasons it is important that the officer supervising the party should take steps to develop supernumerary men of sketching ability.

FIELD SHEETS.

The plane of projection, on a scale of 1500′ to 1″, is divided into 10-inch squares, referred to the center of coordinates, being + or — according to the quadrant. Each 10-inch square usually constitutes a working sheet; the size of field sheets thus depending upon sketching scale. Fifteen hundred feet to the inch, or 1-18000, 1000′=1″ or 1-12000, 750′=1″ or 1-9000, 500′=1″ or 1-6000 are the various scales that have been tried for field work.

Upon first taking the field the 1-18000 scale was used, but it was found that the sketchers could not get in enough detail and that large errors were too easily adjusted. Much of the field work was done on 500′=1″, which scale has numerous advantages. Much detail may be shown, and errors in traverses show up better than on smaller scales. Less country goes on a field sheet, thus causing the sheets to be exposed less to the weather.

One thousand feet to the inch seems to have given the best results, although various officers do not agree as to this statement. Sketching on this proportion, the engineer transparent scale may be used directly for measuring feet, thus tending to avoid errors due to carelessness. Whenever practicable, the field scale should be larger than that of the finished map, All errors will then be reduced when transferred to the final map, thus, an error showing as .01 of an inch on the 1-12000 field sheet will show as an error of but .0066 of an inch on the 1-18000 final map. The scale of the field sheets, just as the scale of the map itself, depends on the nature of the country and the purpose of the map. It is a waste of time to put details on the field sheets that are not necessary for the map, or details that will become too crowded for use when reduced to the map scale.

The most convenient size of sketching board used will hold a paper with working space of 15″ square. The 500′ to an inch scale enlarges the 10″ squares of the map to 30″ squares, thus making necessary four sketching sheets. The 1000′ scale enlarges the 10″ square to 15″, thus making but one sketching sheet. This scale has also the advantage of making computation with coordinates easy and, in hill work, all the country, that can be covered by intersections, can go on one sketching board. This sheet is large enough to permit the plotting of an adequate number of control points for country of this nature. The 1-6000 sheet, covering but one-fourth the area, causes an unnecessary number of close control points.

Each 15″ sheet from the sketching board should be completed and inked in, with the coordinate boundary lines numbered, before being sent to the drafting room. Upon completion of the map, there should be on file the requisite number of 15″ field sheets, each complete in itself and the whole properly indexed to facilitate their use.

Work in the drafting room has been carried on simultaneously with the field work. The control was plotted on vellum paper to the 1500′ scale. The field work has been pantographed on this control, and then traced. The field sheets have all the 100′ contours sketched in, but only such 20′ contours as are necessary to show forms that would be slighted by the 100′ contours alone. The 20′ contours must, therefore, be interpolated before the pantographed map is turned over to the draftsman doing the final tracing. The finished map should in every case be checked from the original field sketches.

Much confusion has resulted with field sheets from the following causes:

Frequently the drafting room has been ready for a field sheet before it was finished, and therefore has asked to have part of a sheet sent in. Sometimes the rainy season or extremely difficult hill country delayed the completion of a field sheet, with the result that the sheet is on file in three or four sections. The use of a sketching table but 14″ square has given a collection of field sheets varying from 8″ square to 14″ square, precluding the successful collecting of a definite number of finished sheets. When several instrumental parties were working from one camp, parts of one sheet may have been run by different parties and the separate parts sent into the drafting room. Field sheets have been sent into the drafting room without the coordinates numbered, and with the + and — signs missing. The draftsman, being familiar with the appearance of the work in hand at the moment, was not inconvenienced by using small pieces of field sheets, or unnumbered sheets, but trouble was caused later in the checking up, especially when due to gross carelessness, not even the coordinate lines were drawn on the sheets.

War Department Doc. 418 not having been published at the beginning of the work, certain modifications were made in the conventional signs then in general use. The reason given for these changes was, that conventional signs were wanted that could be made rapidly and still look well, signs that could be made by an enlisted man without a considerable waste of time spent in practice. Instead of using the conventional water lines, all enclosed bodies of water were cross-hatched. The water along open coast lines was not shown by any conventional sign.

It was early believed that the styles of lettering, as laid down in military manuals, are not adaptable to work done by enlisted men. It was thought that such lettering could not be done, without waste of time in practice, and generally without putting more time on the lettering than on the rest of the drafting of the map. On practically all of the special maps, a system of square letters has been used. In this system, every letter is made by the right line pen alone. Prior to the detail of Company I, Engineers, on the survey, it was the intention to prepare separate name sheets, owing to the fact that the map is so closely covered with details and contours. The final draftsmen have not followed this method, but have placed the lettering directly on the map and have secured very good results, considering that black is the only color used for all work. Since, prior to the detail of Company I, none of the lettering had been done directly on the map, the system of square lettering has not been carried out by this company. Regular lead type, follow-

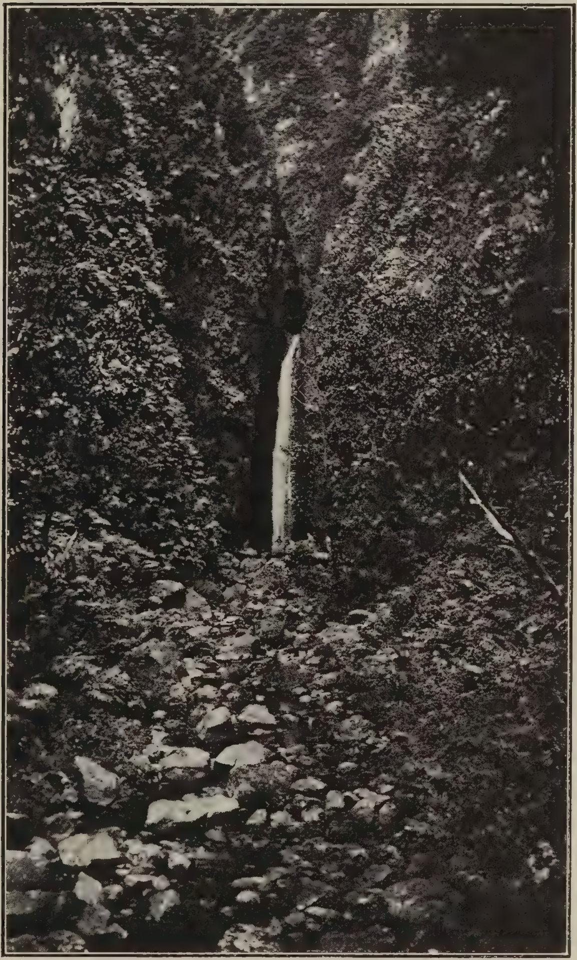


Fig. 3. Kalihiwaa Falls, Oahu Island, taken near preceding picture (Fig. 2). Note the men at the foot of the falls.

ing as closely as possible the styles laid down in W. D. Doc. 418, were bought. A pallet, such as used by bookbinders, is used for stamping names on a straight line when the letters are not spread too far apart. For wide spacing, and lettering on a curved line, each letter is stamped by hand, holding the type in the fingers. No satisfactory ink having been found, a regular pad, as used with rubber stamps, is used. With lead type, this pad gives just a faint outline of the letter. The outline is filled in with waterproof drawing ink, using a crow-quill pen.

Circulars recently have been received from the Multiform Line Stamp Co., 63 Park Row, New York, stating that they can furnish a pallet, containing a templet, that permits stamping on curved lines. They also furnish a type guide and position finder for unusual spacing when the type are impressed separately by hand. The type are inked by using a roller. The circular states that the ink furnished will give excellent results on tracing linen without smearing.

REPRODUCTION.

The original intention was to have the map lithographed, with the lettering in red upon the black map. Lately, it has been recommended that the Lake Survey engrave the map in colors. Negatives have been made from the tracing for use in the Hawaiian Department after the tracings have been sent forward. Photographs of the tracing have been taken, reproducing them to 8 by 9 inches, or 1 inch to the mile. The plates were made by a local photographer at $5.00 each. Good results were obtained, notwithstanding the fact that a makeshift outfit had to be assembled, for the reproduction to scale. Positive films have been ordered for the purpose of reproducing the plates in an unbreakable form. The films will be printed directly from the plates and will give a black line on a transparent celluloid background. From the films, blue prints and brown print negatives may be taken. It is also possible to make a set of celluloid negative films from the positive films.

The Hawaiian Department should have a good map-reproducing outfit for the use of Engineer troops. They should have an equipment such as is in use at the Engineer School. In addition, the number of Engineer troops on Oahu should be increased. The present company has its hands full making the required surveys and doing some of the drafting. A part or whole of the military garrison of Oahu is in the field the greater part of the year. The use of Engineer troops as such, is entirely neglected in the various problems. For the same reason, it is impossible to find time to train the one company in the many duties falling to the lot of Engineer troops in time of war.

COMPARISON WITH UNITED STATES GEOLOGICAL SURVEY METHODS.

United States Geological Survey methods in topographic surveying are thoroughly described in ''Military Topography, Department of Drawing, U. S. M. A.'' ''Wilson's Surveying,'' an excellent book, is written by a former geographer in the Geological Survey. The Survey itself issues a 200-page ''Topographic Instructions,'' which book Engineer officers may obtain for the asking. In the following comparisons, therefore, only such points are touched as differ greatly from those used on the survey of Oahu.

PROJECTION.

The United States Geological Survey would have used the same projection, but would probably not have projected the island as a whole. Using 7½ minutes, an aliquot part of a degree, or 8 minutes an even number, would give fifteen sheets practically the same size as the Engineer survey, and allow a separate projection for each sheet. It has been stated that the method of one polyconic projection for the entire island, rather than for each sheet, has been used because complete maps of the island may be made by merely joining the sheets, reproduced by photographic or other methods. The above opinion is erroneous. In the polyconic projection, the center of the circles reproducing the parallels lie on the central meridian with radii varying as the cotangent of the latitude, thus causing a gradual lengthening of meridianal arc as we depart from the central meridian. The proportionality of the area with separate sheet projections is even more nearly exact than with the one large projection, but in either case, the inaccuracy is infinitesimal on a scale of 1-18000.

In mapping Kauai, an Hawaiian island equal in size to Oahu, the United States Geological Survey did their field work on a scale of ½ mile=1 inch. Each plane table sheet had a separate projection. The whole was combined and published as one map on a scale of 1-62500. In mapping Hawaii, an island of several times the area of Oahu, the Geological Survey divided the map into seventy-three 7½-minute blocks, each making a plane table sheet, with its own projection, on a scale of ½ mile=1 inch. Four of these sheets will probably be joined and published as a 15 minute quadrangle on a scale of 1-62500.

PREPARATION OF FIELD SHEETS.

The United States Geological Survey sheets are laid out by the use of geodetic coordinates, while the Engineer sheets are laid out by arithmetical coordinates. The latter method was chosen, probably, because it was believed to be not practicable to teach the enlisted men geodetic work. By requiring the officers to work out all the positions, and reduce them to arithmetical coordinates in inches, the enlisted man may easily plot the points with reference to his 10 inch squares. The man doing the field work, therefore, never gets beyond plane surveying. This system has led to much extra work and inaccuracies that have had to be corrected. It has been impossible to have an officer in charge of each survey camp and it must be remembered that each camp sometimes sends out several instrumental parties. The system of geodetic coordinates and the construction of a projection for each field sheet can easily be taught the enlisted man. There is no reason that he should not know why the back azimuth differs from the forward, especially when it differs as much as 1 minute in a 3 mile east and west line.

HORIZONTAL CONTROL.

In most work of the present day, the surveyor can usually find that primary control has already been established. Before commencing work, the records of other Government organizations should be examined in order to make use of all available data. Primary triangulation does not vary much with different organizations. Methods in use are similar, the nature of the work done and instruments used depending upon the accuracy desired. For secondary control, the plane table is used by the United States Geological Survey with intersections, and resections from the primary points. Also, they use the so-called ''Primary Traverse,'' especially in heavy forested and level country. Primary traverse does not differ from the usual traverse in the general methods of execution, but does differ in the elaborateness of detail. Very little primary traverse was used on Kauai. More will be necessary on the island of Hawaii. It was not used at all by the Engineer troops on Oahu. It is sometimes very useful, and officers should make themselves familiar with the details and the checks necessary.

VERTICAL CONTROL.

The main vertical control work, that has been done on the Hawaiian Islands by the United States Geological Survey, has been by spirit leveling; the precision of which has depended upon the nature of the country. It must be remembered that all Geological Survey parties are restricted by cost. More money must not be spent than is justified by the nature and importance of the country. Such limit determines the length and precision of the spirit leveling.

In running traverses, height measurements are also affected, by the United States Geological Survey, either by vertical angulation or by the aneroid used differentially. Vertical angulation is used in particular, whenever points are not occupied, but are located by intersection on the plane table. In the beginning, the Engineer troops ran several careful level courses, in order to check elevations of the island triangulation stations. The country was so difficult for careful level work and the elevations of the stations checked so well, that afterwards only angle determinations were used, based on the Territorial Triangulation.

Page 282, App. 3, C. and G. S. Report, 1902, declares it to be ''useless to aim at a high degree of accuracy in vertical measurements, since the irregular variation of the refraction, from hour to hour and day to day, produces changes in vertical angles which affect the tens of seconds and, sometimes, even the minutes.'' In making the California-Washington Arc of Primary Triangulation, the Coast and Geodetic Survey did work showing that the above statements should be modified. Elevations of the stations in this arc were fixed by three methods: Those by precise leveling, are subject to a probable error varying from 0.15 to 0.3 meter; those by reciprocal measures of vertical angles, are subject to a probable error of ± .2 to ± 1.1 meters; and those by nonreciprocal angulation, the intersection stations not being occupied, and whose elevations are subject to probable errors which may be as great as ± 3 meters in some cases. The results obtained by trigonometric leveling, primary or secondary, as compared to corresponding spirit leveling, are of far greater accuracy than ordinarily supposed. The choice, by the Engineer troops, of the former seems to be justified.

FIELD WORK.

The military map is on a larger scale and should show more detail than would be necessary to serve the purpose of a corresponding United States Geological Survey map. The Engineer troops in making the map, are obtaining training in surveying, camp life, pack train and familiarity with the terrain; training that would otherwise be given in the nature of drills. For these reasons the Engineers may afford larger survey parties, using more trail cutters than the United States Geological Survey, and traversing the hill country very closely, while the latter place more dependence upon intersections. The plane table has not been used on the military map of Oahu. The reasons given by the officers of A and G companies being as follows: "The plane table was not used, as it was found that the men could do more accurate work by the other method. In addition, the table was very hard to carry up hills and through brush and there were few locations where sufficient detail could be sketched without frequent setting up. The plane table equipment of the companies was obsolete and in poor condition, and therefore the method was not given a fair test; nevertheless, it was believed that better results could be obtained by enlisted men with the transit and sketching table, two men doing the work rather than one with a plane table."

The United States Geological Survey use either the stadia traverse, or, whenever practicable, the wheel traverse, making use of a wagon wheel, a method that has not been tried on the military map survey. The table is oriented by the needle, by use of the Baldwin Solar Chart or by back and fore sights. The plane table facilitates the use of resections and intersections. In the case of the Engineer sketching board, intersections may be used by plotting the transit angles with the transparent protractor. More often though, side shots are obtained by using many rodmen and plotting azimuth and stadia distance. If the Engineer surveyors use the method of resections the problem is solved analytically.

The Engineer companies should make greater use of the plane table. If the equipment does not include an up-to-date table in good condition, the company should take steps to get one. The plane table is a most simple, direct, and economic instrument. It certainly should be possible to develop plane table men among the enlisted men. To do so, requires only that the officers of the company give the work proper supervision, without which very few enlisted men will give accurate results with any instruments. Very poor topography has resulted when sergeants in charge of parties were allowed to sketch in prominent features of very difficult country by means of intersections. For this reason the Engineer

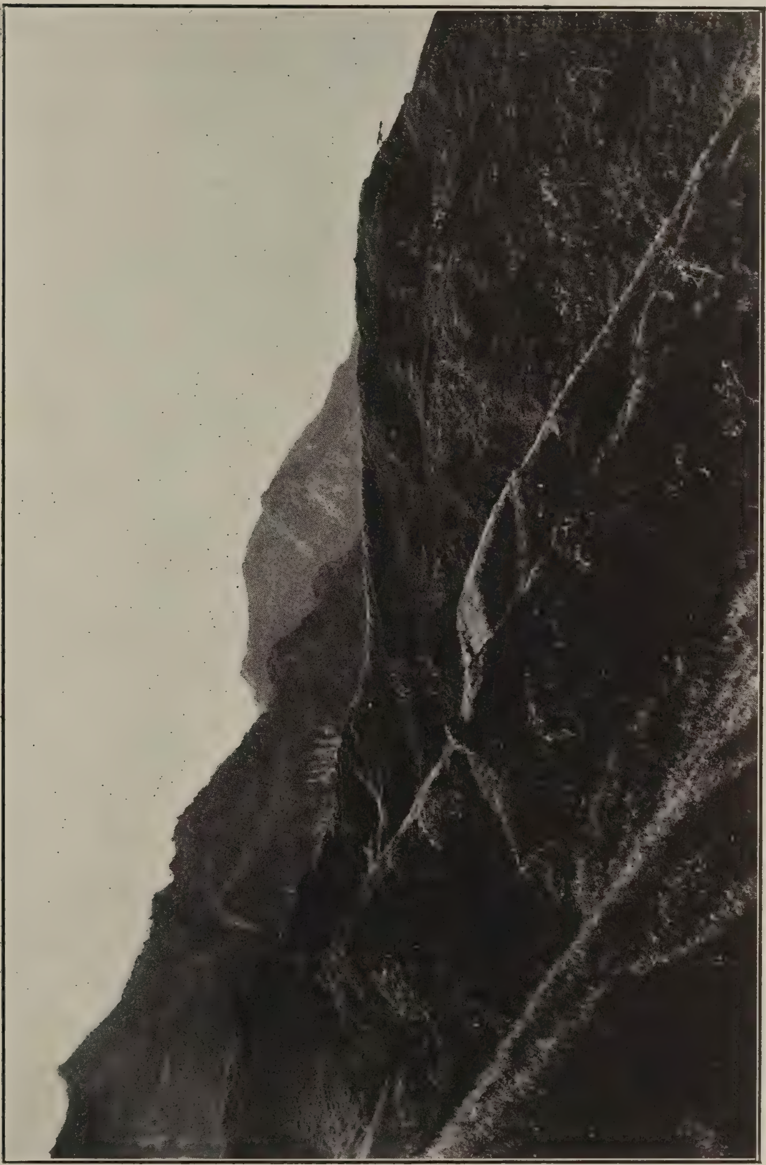


Fig. 4. View near east coast, Oahu Island.

troops have covered all terrain of topographical importance by traverses preceded by trail cutters.

In difficult country of dense forest and undergrowth, the United States Geological Survey uses stadia traverse with the plane table, combined with a great number of intersections. If a lack of prominent features puts a narrow limit on triangulation methods, the so-called ''Tape Traverse'' is used. The method is applicable only to scale of 1-48000 or smaller. A plane table, 9 inches square, with compass attachment is best for the work. A sight alidade, pocket compass, and 528 feet of tailor's linen binding tape, marked at 100-foot intervals, are also required; but one chain man and no trail cutters are necessary. The sights are taken in the direction shown by the tape, or sound signals are given by the chain man. Elevations are taken by the aneroid barometer. The details of the work and the precautions to be taken are given in ''Topographic Instructions, U. S. G. S.''

Methods used depend upon the importance of the country as related to the purpose of the map. Parts of the hill country of Oahu, though ordinarily not visited by man, are believed to be of military importance, requiring the map to be accurately made on the scale 1-18000. For such work, a small plane table with telescopic alidade, in size corresponding to a mountain transit, should prove of value. A plane table does not necessarily have to be bulky, in order to give accurate work. Many people would be surprised to know what accurate work can be done with a small mountain transit. Similarly, it is believed, accurate results could be obtained with a small telescopic alidade.

FIELD PAPERS.

All the field work has been done by the Engineer troops on vellum paper. A piece of vellum, 15″ square, by the alternate use of sunshine and water, may be made to stretch as much as three-tenths of an inch in one direction while it will stretch but one-fourth as much in the other direction. The hill country of Oahu is subject to large atmospheric changes, there being much rain and fog. A paper should be used that is affected slightly, and if possible, uniformly in all directions. Any variations in the dimensions may then be largely eliminated by a uniform reduction or enlargement of scale. The United States Geological Survey use a double-mounted plane table paper. To each side of a piece of cotton cloth is pasted a sheet of the best quality heavy drawing paper, so oriented that the grain of the two sheets cross at right angles. The result is a sheet that is least affected by atmospheric changes and almost uniformly in all directions. Applying the same test as applied to the vellum paper mentioned above, shows a uniform change in dimensions of about one-twentieth of an inch in 20 inches. Medium atmospheric changes, that affect vellum to a large extent, have no appreciable effect upon the double-mounted paper. Celluloid sheets having a white, opaque surface, are also used by the United States Geological Survey, especially in the hill country where there is much rain and fog, and the underbrush is wet at all times. Celluloid gives an excellent pencil drawing surface, not affected by water. Its change in size with temperature change is negligible.

DRAFTING AND REPRODUCING.

The United States Geological Survey topographer habitually finishes a complete field sheet prior to submitting it. He is usually given a certain period of office time to ink and letter his sheet. The standard colors given for conventional signs in W. D. Doc. 418 are used. Many people have the mistaken opinion that these colors can not be mixed, to give good results in reproduction or in blue printing. The Oahu tracings would be much more legible if done in colors. The United States Geological Survey field sheet, upon arrival at Washington, is complete in itself and ready for reproduction. No pantographing nor tracing is done. By drawing, on the ground glass of a photographic reproduction outfit, the meridians and parallels, an accurate photographic map is obtained for the engraver's use.

"Instructions to Topographers" gives excellent paragraphs on the placing of contour figures, lettering and proofreading of sheets. Several of the rules therein given that have not been closely followed on the Oahu map are as follows: All names to be placed so as to be readable from the bottom of the map. Names parallel to a meridian are to be read from south to north. When townships, land grants, etc., are long and narrow the names are to be placed lengthwise through them, in sweeping curves if appropriate. The size of the letters and contour figures is to be commensurate with the scale of the map.

Discussion

Capt. WARREN T. HANNUM
Corps of Engineers

LOCATION AND EXTENT OF OAHU.

The Island of Oahu, third in size of the Hawaiian Islands, formerly known as the Sandwich Islands, lies in the Pacific Ocean just south of the Tropic of Cancer and approximately 2,000 miles from the California Coast. The islands of the group are of volcanic origin and geologically are of recent formation, though all the islands are not of the same age, the island of Hawaii being of the most recent formation and still the scene of volcanic action.

Oahu, near the middle of the group, has an area of approximately 600 square miles, the maximum difference in latitude being 28 miles between Kahuku Point on the North and Diamond Head on the South and the maximum difference of longitude being 37 miles between Makapuu Point and Kaena Point.

PHYSIOGRAPHY.

The island consists of two mountain ranges approximately 15 miles apart whose general trend is in a direction similar to that of the line formed by the group of islands, N. W.—S. E., and between whose summits, approximately 12 miles apart, lies a broad central valley which includes most of the habitable, cultivable portion of the island. The crests of the mountains are approximately only 2 to 3 miles from the coast line, leaving narrow strips of low land along the shores which are parallel to the summits.

One range, the Koolau Mountains, on the windward side, extends from Makapuu Point at the southeast in a continuous unbroken ridge to the north end of the island where it breaks up into a number of ridges running down to a shore line terminating at Kahuku Point. The Waianae Range on the leeward side extends from Kaena Point on the northwest to the shore line on the west coast about 5 miles from Barbers Point on the southwest.

Each of these ranges extends in a continuous unbroken ridge from end to end, the ridge being very sharp and in some places so narrow one may sit astride of it one leg on the exterior and the other on the interior slope of the mountain. The ridges are a series of sharp peaks rising several hundred to more than a thousand feet above the saddles between the peaks, the saddles having elevations one to two thousand feet above the sea. The highest peak on the Koolau Range is Konahuanui, 3,105 feet above the sea, on the south side of the Nuuanu Pass behind Honolulu. Mount Kaala, 4,030 feet above sea level, is the most elevated portion of the Waianae Range. It is situated about the middle of the range and north of Kolekole Pass. At its base on the south side lies the military post of Schofield Barracks.

From the crest of the Waianae Range, lateral ridges extend toward the coast with intervals of 1 to 5 miles between them, thus forming large natural ampitheaters open towards the sea. The floor of the inclosed area rises gradually from the coast inland between the lateral ridges with a gentle gradually increasing slope till the elevation of 500 to 700 feet is reached a few miles from shore, when the rate of increase of slope becomes greater till the last thousand feet of elevation is attained on slopes of 45 to 90 degrees.

On the exterior slope of the Koolau Mountains the formation is somewhat similar, except that along the southern half of the main crest lateral ridges are much farther apart, the floor of the intervening space more undulating and the slopes on the main ridge at the heads of the intervals are extremely precipitous, being nearly vertical. In the northern quarter of the Koolau Range, beginning at the district of Punaluu the crest of the range loses its knife-like edge and broadens out for several miles to the north, the lateral ridges are very close together, forming very narrow valleys whose watercourses are interrupted by falls varying in height from 30 to more than 100 feet. This section of the island is the most difficult to traverse, it being improbable that one would reach the summit at first attempt unless one had knowledge of the route to follow. At the extreme northern end the crest becomes narrow again and finally divides, running down to the north end of the island in a number of spurs which are not so sharp crested and between which the valleys are not so narrow nor so deep.

The interior slopes of the two mountain ranges meet along the Waikele and Kaukonahua gulches, approximately 10 miles from the crest of the Koolau Range and 5 miles from the crest of the Waianae Range. These slopes form the central valley, which rises from the north and south shores to an East-West divide included in the U. S. Military Reservation of Schofield Barracks in central part of the island. The lowest part of the divide has an elevation of about 800 feet.

The interior slopes are quite different from the exterior slopes of the main ranges. There appears no distinct lateral spurs extending from the crest except on the Waianae Range, where there is one extending from Mount Kaala towards the East, approximately 3 miles to a hill called Maili, whence it drops off into the Kaukonahua Gulch. Numerous gulches whose general directions are perpendicular to the direction of the main ridges, cut into the faces of these interior slopes in some places on the Koolau slope reaching a depth of more than 500 feet. The gulches are not so pronounced on the Waianae slope.

On the Koolau Range the interior slope is thus a succession of ridges and valleys. On the sides of these ridges at numerous places are visible long layers of lava rock, one upon another, giving appearance of stratification, the beds of which are inclined towards the main ridge. The last 500 or more feet of elevation on the interior slope is gained very rapidly and the numerous valleys near the summit are reduced in number by several uniting into one, resulting in broad ridges at the lower levels, whereas in the higher levels, above 1,200 feet elevation, the ridges assume the characteristic formation of sharp crest, steep side slopes, and a succession of small peaks.

NATURAL VEGETATION.

There is no forest cover on the island, except a low growth on the slope of the mountains extending varying distances from the summit.

On the Koolau Mountains the cover of the interior slopes extends down to an elevation of about 1,200 to 1,500 feet on the lateral ridges and to a slightly greater distance in the intervening valleys where the vegetation is protected and receives more moisture. On account of greater rainfall on the windward side, the forest growth extends to a lower altitude.

At the lower limits of this forest cover along the ridges, there is a growth of very dense fern and high coarse grass which occasionally conceals old cattle trails worn 1 to 2 feet deep, into which one sometimes falls unexpectedly. The ferns are waist to shoulder high and while growing in a dense mass, have not strength to support the weight of a man. It is possible to break through without cutting, except when one becomes entangled in a creeper vine, but progress is slow and exhausting. The ferns grow also at higher altitudes, but not so densely except in spaces not covered by other growth.

Between the fern line and the cultivated areas below the vegetation consists mainly of coarse grass, which is light green or brown depending on the amount and frequency of rainfall, and guava bushes which offer but little impediment to one's progress. The guava bushes, though generally of low growth, 3 to 6 feet on the ridges where exposed to the wind, in the upper parts of many of the valleys, grow to trees of considerable size, trunks measuring about 6 inches in diameter. In this area and indeed at lower altitudes where the soil is not cultivated are found the lantana and the ''klu'' bushes, the latter a specie of mimosa, which usually grow less than 5 feet high, both armed with thorns, making passage through a clump of them slow and often painful, though the lantana by reason of its short sharp thorn and stiff branches is the most objectionable, not only penetrating but tearing one's clothing. The lantana, especially, is a pest detested by all alike, though it is said to have been originally imported to beautify grounds by using it for hedges. It is easily identified by its varicolored flower.

Above the ferns the tree growth begins. One hesitates to say timber growth, because that generally conveys the idea of trees yielding wood suitable for constructive purposes, in which class the tree growth on the hills of this island does not belong. At the lower altitude the trees are scattered, but become more dense higher up. However, along the ridges where they are exposed to the high winds their growth is stunted and they are twisted and knarled. In the valleys and in the ravines on the slopes of the ridges where protected from the strong winds and where there is more moisture, a few trees do occasionally grow to a size worthy the name. In general, the vegetation consists of scrub trees and a very heavy underbrush.

The vegetation on and near the summit of the main ridge is very low, high growth being prevented by the strong wind. The growth of low brush is so heavy as to completely conceal the underlying soil, and in some places is so closely matted one can walk upon it without breaking through.

Progress is slow and work laborious in opening a foot trail through such a growth and over such steep slopes. In some places parties of six or eight hardened men have advanced but 300 yards in a day.

On the Koolau Mountains this forest cover extends about 3 to 4 miles down the interior or western slope and probably less than a mile to two miles down the exterior or eastern slope, the shorter distance in the latter case being due to the more rapid fall toward the lowlands adjacent to the coast.

By reason of the lack of rainfall the vegetation on the Waianae Range is sparse, except on the slope of Kaala and vicinity, but is of the same character as described above.

On the coastal plane along the south and west shores extending back into the valleys there are large growths of Algaroba trees, the beans from which are ground into a feed for animals and the wood used for fuel.

WINDS AND RAINFALL.

The trade winds blow from the North East. The moisture carried by them is precipitated upon striking the heights of the Koolau Mountains, much of it falling upon the windward slope but some falling on the leeward slope. The moisture carried by N. E. winds, being precipitated by the Koolau Mountains, the Waianae Mountains on the West receive but little if any rainfall when the trades are blowing, except when the wind passes around the north end of the Koolau Mountains and gives up the moisture upon the windward side of Kaala, the high peak of the Waianae Range.

As the trades from the northeast are the prevalent winds, the west coast has very little annual rainfall which occurs when a ''Kona'' or South wind blows, at which time, too, the entire central valley receives a copious supply of water. ''Konas,'' however, are infrequent. The west coast has quite a barren appearance, except where the soil is under cultivation, water for irrigation being obtained from deep driven wells and from filtrations into tunnels built into the talus at the foot of the slopes of the mountains near the heads of the valleys.

The mean annual rainfall varies greatly on the island, although it is only about 31 inches near the water front of Honolulu in the valleys behind the city and a few miles from the shore it varies from 50 to 90 inches. On the west side of the island it is about 20 inches while on the northeast or windward coast it reaches 100 inches. Rainfall may be expected almost daily in some parts of the Koolau Range, varying from occasional showers to heavy down-

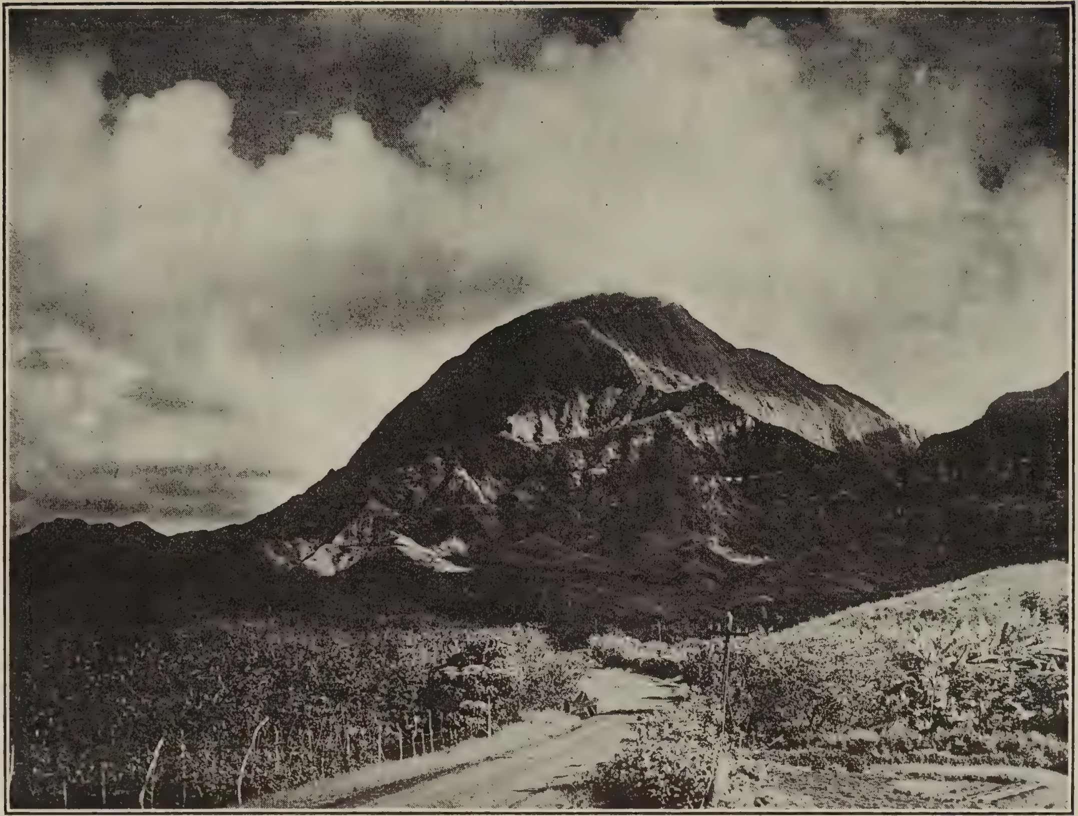


Fig. 5. Konahuanui (3,105 feet above sea). Highest peak in the Koolau Mountains. The Pali Road passing to Honolulu through the low saddle (Nuuanu Pali) on the right, is cut out of the face of the steep slopes of the mountain

pour, especially in the hills at the headwaters of the Kaukonahua stream about the middle of the Koolau Range.

CULTIVATION AND OTHER USE OF LAND.

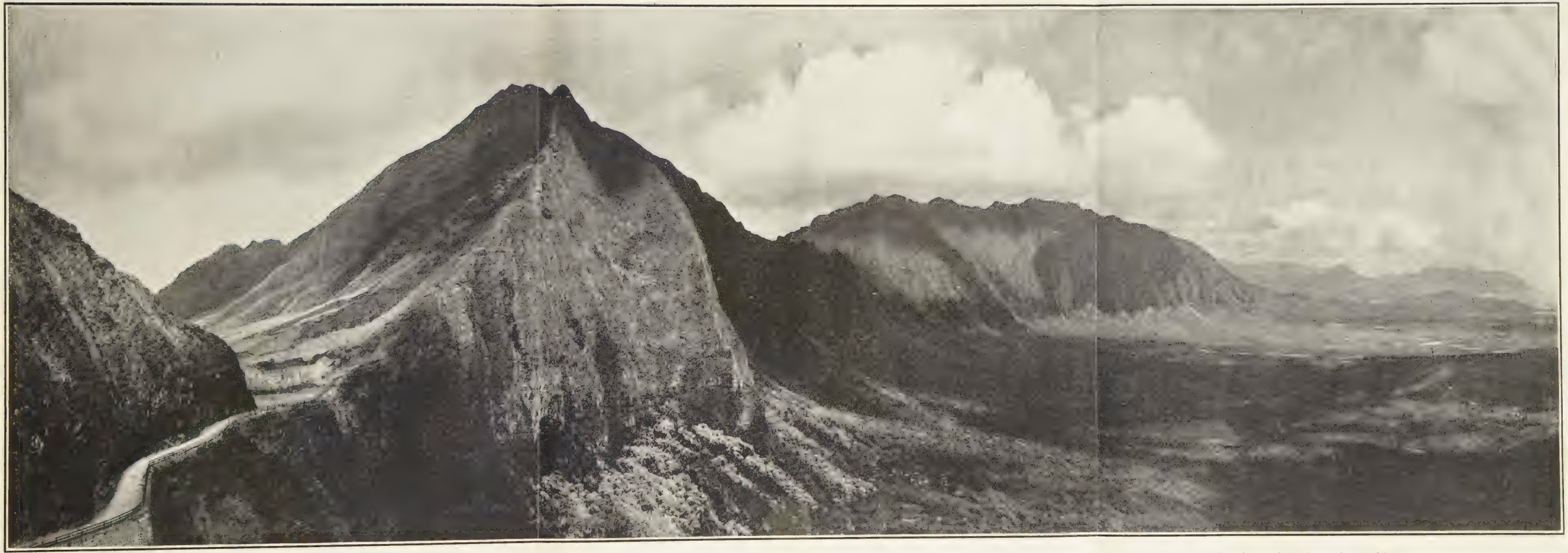
The staple crop of the island on which prosperity has depended has been sugar. Sugar cane fields generally cover all cultivable parts where water can be obtained in sufficient quantity for irrigation. Except parts of the lowlands near the shore which are used for cultivation of rice by the Chinese and except portions of the low coral plain in the vicinity of and to the west of Pearl Harbor, the land on the south side of the island between the two mountain ranges and west of Honolulu is occupied by cane fields to an elevation approximately 500 feet above sea level, beyond which the sugar companies find the cultivation of cane unprofitable on account of the expense of pumping the water to irrigate the fields, the quantity and frequency of rainfall being insufficient for a profitable growth of cane. On north slope of central valley the Waialua Sugar Company grow cane at an elevation of 750 feet, obtaining water from large storage reservoir at Wahiawa on the divide.

The same conditions in general exist on the north side of the island, except that rice fields are scarce. The land, 4 miles along the north coast east of Kaena Point is used for cattle grazing, though the first few miles are generally rocky and barren, not capable of supporting much life.

The high tableland of the central valley above the cane fields where cultivated is, in general, used for growing pineapples, though there are a few square miles of sisal plantations. There is a considerable area of the uplands of this valley uncultivated, including the area occupied by the Military Reservation on the divide, though the cultivation of pineapples in this region is being rapidly extended.

About half way up the west coast the Waianae Sugar Company has developed large cane fields. Otherwise, the land on this side is practically uncultivated, although there is a coffee plantation in the hills of district called Makaha.

From Kahuku Point on the north coast the cane fields of the Kahuku plantation extend about a mile to the west and several miles down the northeast coast to the vicinity of Punaluu. The lowland of the valleys of this and several succeeding districts to



Koolau Mountains and Windward Oahu. Road through Nuuanu Pali on left. Primary triangulation station (can on iron pipe set into concrete base) a short distance to the right of road on sharp ridge.

the south are under rice cultivation. The pineapple fields begin in Punaluu and extend south to the Nuuanu Pali, pineapples being grown in greatest abundance in the vicinity of Kahuluu although much of the land south of Punaluu is not yet under cultivation, due to lack of transportation facilities, there being no railroad and water transportation by sea to Honolulu not being well developed.

At the extreme southeast end of the island on the windward side between the steep walls of the Koolau Mountains and the shore are the cane fields of the Waimanalo Sugar Company.

On the south side of the island from Makapuu Point on the east to Koko crater, the land is very dry and is a desert waste. Thence to Honolulu the land is principally used for cattle grazing and dairying.

Taro, a plant the root of which is used in making the native ''poi,'' is extensively grown in the valleys behind Honolulu and fields of it are found scattered along the windward side of the island supplying local demand.

CAUSE OF SURVEY.

The storm water drainage from the catch-basin between the mountains and south of the divide in the central valley is discharged into a bay called Pearl Harbor, divided into three principal arms by two low lying peninsulas extending down into it from its north shore. With the included peninsulas and Fords Island it occupies an elliptical area 5 miles long by 3 miles wide, the length parallel to the general direction of the south coast line. The entrance from the sea is by a channel ½ mile wide and 2 miles long. On the east shore of this channel where it enlarges into the bay is situated the U. S. Naval Station, the development of which as a naval base necessitated its defense, not only from attack from sea but also by land. In order to determine a location and disposition of the land defense lines, a topographical survey of the island was ordered and executed as described by Lieutenant Besson. The hydrographic survey adjacent to the coast line has been made by the U. S. Coast and Geodetic Survey. The results of these surveys are confidential and not available for publication at the present time, but a map published by the office of the territorial surveyor gives an idea of some features of the island.

OBSTACLES TO PROGRESS OF SURVEY.

From the description above it may be judged that the physical features of the island were nearly ideal for the execution of a topographical survey. Except where forest cover existed on the slopes of the mountain ranges, necessitating cutting of trails and clearing on the small peaks in order to make observations, there are no dense woods to obstruct the view, and the formation of the land is such that stations can be established for triangulation as close together as desired without the necessity of constructing towers or platforms for observation. It was necessary to establish a few tree stations on lateral ridges.

The temperature of the air permitted the work to be carried on at all seasons of the year. It is never cold except in the mountains, above 2,000 feet elevation, where the nights are chilly and damp. The heat of the days in midsummer is mild, at no time requiring suspension of work. There are no wild animals in the hills, except domestic animals which have wandered away. There are no snakes, and few if any poisonous insects or plants. The only natural causes for suspension of field work were rainy or, in the mountains, foggy weather, and then when possible the time was utilized in camp working up notes or other information. Each detachment camp was provided with drafting materials and a tent for office work.

CONDUCT AND HEALTH OF ENLISTED MEN.

During more than a year's field work by Company I, Third Battalion of Engineers, no complaints against the conduct of the members of the surveying parties were received from property owners, but on the contrary praise of their good conduct and bearing has been given. One detachment operating in the vicinity of Hauula on the windward side of the island assisted in the rescue of a party of five civilians lost in the mountains of that vicinity, some discovering and leading back to safety three of the party and others assisting in the rescue of the remaining two, one of whom was injured and unconscious. The health of the detachment in the field has been excellent. There have been no losses due to disease or injury among the members of the last company engaged on the work. Typhoid fever has been unknown, all members of the company having received the prophylactic treatment for prevention thereof. During the same time several soldiers from other organizations have lost their lives in the mountains by falling over precipices. The greatest loss of services of men in the field was due to minor cuts and bruises and mainly to skin infection resulting in development of large sores slow to heal on the hands, arms or legs of the men.

RAILROADS.

A narrow gauge railroad, beginning at Honolulu, runs west, skirting the north shore of Pearl Harbor to Barbers Point at the southwest corner of the island, thence along the west coast close to the shore line, passing around the northwest point (Kaena Point) of the island and thence follows the north and northeast coast generally within a few hundred yards of the beach to Kahana about half way down the northeast coast. A branch of the railroad is operated between Waipahu, at the head of the middle loch of Pearl Harbor, and Wahiawa and Schofield Barracks on the divide in the central valley. There are branches from the main railroad connecting with a few of the large pineapple plantations and also branches, owned usually by the sugar companies, connecting with the mills and pumping stations of the sugar plantations and also serving to haul the harvested cane from the cane fields to the mills. Such branches were not available for transportation of supplies to detachments in the field, there being no regular freight service over them.

WAGON ROADS.

A good wagon road passes through the Nuuanu Pali behind Honolulu to Windward Oahu, where it extends to the Waimanalo Sugar Plantation to the southeast and also up the coast past Kahana, the terminus of the railway. The road continues around the north point (Kahuku Point) to Waialua, about the middle of the north coast. Thence the road extends south through the central valley, past Wahiawa and Schofield Barracks to a point near Pearl City on the north shore of Pearl Harbor where it divides, one branch running east to Honolulu and one west through Waipahu to Barbers Point and up the west coast parallel to the railroad to within a few miles of Kaena Point. Parts of the roads described are improved earth roads. The road between Honolulu and Waipahu and Waialua on the north coast is oiled macadam. An unimproved road also extends from Waialua on the north coast west toward Kaena Point, but no wagon road passes around the point. Unimproved wagon roads branch from the main roads described, passing through the cane fields and pineapple plantations and usually some distance into the valleys between the lateral ridges of the mountain systems.

LOCATION OF SURVEY CAMPS.

When a detachment was sent into the field, a site for the main camp was selected, if practicable, within the area to be surveyed and within easy hauling distance of the railroad station. The round trip from camp to railroad was usually accomplished in a few hours. As many field parties as conditions warranted, composed as described by Lieutenant Besson, were assigned to a camp, though usually there was but one such party and sometimes a triangulation party establishing and locating stations.

SUPPLYING CAMPS.

A non-commissioned officer was assigned in charge of the administration and supply of each camp. He telephoned or sent by mail to the company office in Honolulu requests for all supplies, subsistence, Quartermaster or Engineers as needed. Non-commissioned officer detailed for the purpose and assisted by four men, received the requisitions, collected, packed, and shipped the supplies. Supplies were sent by rail to the nearest station and hauled to the main camp.

FIELD WORK.

The field parties, carrying light lunches with them, left camp about 7 o'clock in the morning and returned between 4 and 5 in the afternoon. Field work began at the beach or in the central valley and extended toward the crest of the mountains, traverses generally being run up the valleys and lateral ridges connecting to triangulation stations were established. When the work had progressed so far that the time required to proceed from the camp to the beginning of the day's work prevented a reasonable amount of mapping daily the field party would go out, carrying sufficient rations to permit them to remain away from the camp for several days. Generally, the conditions required more than a few days work to reach the limits of the area to be mapped and then subcamps would be established as far toward the crest of the main ridge as practicable, to which supplies and, in some cases, water were carried either by pack animals or on the backs of the men. Over the trails cut above the timber line the rate of travel was very slow, seldom exceeding 1 mile per hour, so that distance was referred to by the time required to cover it rather than by any linear dimension, which failed to convey a correct conception of the difficulties to be overcome.

SURVEYS BY ENGINEER TROOPS.

It is seldom that Engineer troops are called upon to make an instrumental survey of such a large area. In time of war, if complete maps of the theater of operations were not available, maps would be made by the methods of rapid reconnaissance, using such control as might already exist or establishing a scheme of control capable of rapid development and ignoring any great precision. The military reconnaissance map of the entire island of Cuba was made in this manner in 1907-1908. In recent years the instrumental surveys on which Engineer companies have been engaged were undertaken for the purpose of making maps for locating and laying out military posts, principally in our island possessions—for use during maneuvers—for preparation of plans for land defenses and for marking and describing the boundaries of military reservations. Such surveys have been over limited areas requiring the application only of the principles of plane surveying. Excepting the instrumental survey of the Island of Luzon, Philippine Islands, the survey of Oahu has been the first work of magnitude undertaken by Engineer troops in recent years. From what I have been able to learn the work on Luzon is not as thorough as that undertaken on Oahu.

PRIOR MAPS OF ISLAND.

As explained by Lieutenant Besson, the original instructions required the survey of limited isolated areas only. When it became necessary to include the entire island in the survey it required the introduction of geodetic principles to maintain a proper control and the selection of a projection, scale, relief and other details of the map. A cadastral map of Oahu, prepared by the office of the Hawaii Territory Survey, served as an excellent guide.

Reproductions of the map to scale 1 inch = 7,500 feet and 1 inch =5,000 feet were available. Relief was indicated by hachuring, consisting mainly of an outline of the mountains and some lateral ridges and a few deep gulches in the central valley. It assisted greatly by giving name and location of places and divisions of land, which were accurately delineated where land surveys had been made but were found very inaccurate in places where no surveys had been made, especially along the western slopes of the Koolau Mountains. The only vertical distance definitely indicated were the elevations of the triangulation stations and of some peaks. Railroads and main highways were represented. The trigonometric control is explained by Lieutenant Besson.

Astronomical observations for latitude had been made at two stations on the south coast and one on the north coast by representatives of the U. S. C. & G. S. in 1887 and results published in pamphlet entitled, ''Determination of Latitude and Gravity for Hawaiian Government,'' Appendix 14, Report of 1888, U. S. C. & G. S. The Hawaiian Government Survey having determined the geodetic coordinates of all the stations of the primary triangulation, much labor was avoided in the preparation of the control.

PROJECTION.

The projection adopted was the polyconic projection as described by Lieutenant Besson, who apparently believes that each of the fifteen sheets of the survey should have had its own projection instead of including the entire island in one projection, the separate sheets forming equal divisions thereof, and also that each field sheet should have been projected separately, as is stated to be the procedure followed by the Geological Survey, though the latter seldom, if ever, uses as large a scale as 1:18,000 in mapping an area equal in extent to Oahu.

The writer would agree with this opinion had the original instructions required the survey of the entire island. As such instructions were not given, one must consider and allow for all conditions as they existed at the time orders were issued extending the limits of the areas to be surveyed. It was of importance that the survey be completed without unnecessary delay. Under the circumstances those confronted with the problem should have been the ones best able to decide and I would not say that, everything considered, the projection as developed did not result in the accomplishment of the work in the most expeditious and satisfactory manner.

The method of making the map was chosen in 1909, while Company G, Second Battalion of Engineers, was working on the project and, naturally, it was continued when the work was taken up by Company I, Third Battalion of Engineers. The method may be stated as follows: A polyconic projection of the island as one unit. The central meridian of the projection was selected and a point on this was chosen as the origin for a system of rectilinear coordinates to which the position of all points of control were to be referred. The stations of the primary triangulation system whose geodetic coordinates were given were projected upon the map and their rectilinear coordinates determined referred to the origin selected. The projected positions formed the main control which was extended as necessary, usually by triangulation based upon a side of the primary system using the projected length of the side as determined by the rectilinear coordinates of the stations at the ends of the base. The principles of plane trigonometry only were applied in the computations and thus the positions of all control stations were represented by rectilinear coordinates referred to a common origin, and all parallels and meridians were neglected on the field and control sheets, but were later platted on the finished maps.

The method used had the disadvantage of requiring the determination of the rectilinear coordinates on the projection used of twenty-eight primary triangulation stations, a few secondary stations. It had the advantages of permitting the work to be carried on with the knowledge the men already had, of avoiding the necessity of preparing projection tables for the scale of the map, and also of instructing men in the use of the tables and in the principles of spherical trigonometry to enable them to compute the geodetic positions of new control stations and to plat their positions.

It will be admitted that had the conditions permitted it would have been more beneficial to the men to have carried instructions beyond plane surveying into geodetic surveying. However, the resulting map is as accurate as it would have been had the usual method been adopted, because the system of triangulation based on a projected side of the primary system extended generally in no direction more than 6 miles, the length of the projected side approached the true curved distance between the primary triangulation stations rather than the chord distance, and the triangles of the tertiary system were so small that any error involved in failure to consider them geodetic surfaces would be inappreciable.

As stated, the field sheets were not uniform in size. Supposing they could have been made of uniform size, approximately 16 inches square, including an area 3 miles along the meridian by 2 2-3 miles along a parallel, nine field sheets would have been required to each of the fifteen sheets of the completed map. The convergence of the middle and extreme meridians on such field sheets would not have exceeded 3½ feet, represented by .0035 inch for the scale used. The greatest variation from the perpendicular to the central meridian would have been less than seven-tenths of a foot or less than .0007 inch on the field sheet. Such small intervals, of course, could not be platted and therefore in a polyconic projection for a field sheet of the size stated meridians as drawn would have been parallel and parallels would have been perpendicular thereto. Under such circumstances it would require but little instruction of field parties to prepare a projection of a field sheet, having given the lengths of the units of latitude and longitude in the included area.

If a polyconic projection for each of the fifteen final sheets had been prepared, the convergence of extreme meridian upon the middle meridian would not have exceeded 18 feet or twelve-thousandths of an inch on the map, and the parallels would not have departed from the perpendicular to the middle meridian by more than 4 feet, twenty-six ten-thousandths of an inch on the map. The latter interval could not be platted. The former interval is about the width of a pencil line and requires considerable care to detect. Therefore, had each sheet of the map received its own projection the parallels would have all been perpendicular to the central meridian and if any convergence of meridians could have been distinguished it would have been so small as to be completely obliterated by the slightest distortion of the paper on which platted. Projecting the map as a whole, the convergence of the extreme meridian toward the middle meridian did not exceed 360 feet, twenty-four hundredths of an inch on the map, while no parallel departed from a perpendicular to the central meridian by more than 118 feet, eight hundedths of an inch on the map.

Had the topography of the island been represented on fifteen sheets, each sheet covering an area eight minutes in latitude by eight minutes in longitude and each sheet with its own projection, as suggested as the probable method which would have been followed by the Geological Survey, on each sheet the parallels of latitude would have been perpendicular to the central meridian and the extreme meridian would have been right lines with a convergence toward the central meridian of a little more than one-hundredth of an inch. The extreme parallels on any sheet would have had the same length as the corresponding parallel on the sheet covering the adjacent area to the north or south. Therefore no trouble, except that due to distortion of the paper on which the map had been drawn or reproduced, would have been experienced in joining the fifteen sheets together to represent the entire island.

Theoretically, in a polyconic projection the meridians are all concave toward the central meridian and therefore the edges of adjacent sheets in the same latitude do not coincide, but practically they do coincide in the projection of small areas.

Lieutenant Besson, in his paper, states that the following statement means nothing: "that the method of one polyconic projection for the entire island, rather than for each sheet has been used because complete maps of the island may be made by merely joining the sheets, reproduced by photographic or other means." From what has been said above, it will be seen that practically his assertion is correct, but theoretically incorrect.

It was realized that the map reproduced to the scale 1:18,000 would be inconvenient for use of troops in the field where a map of the entire island on one sheet would be required, and therefore the original would have to be much reduced, preferably by photography, and the meridians and parallels of the reproduction would thus be correctly represented if the entire island were on one projection. Again, this permitted the location of projected positions of all primary stations forming the control of the survey to be represented by rectilinear coordinates referred to a common origin. Thus it was possible to use a system of rectilinear coordinates, the use of which the men already understood.

The methods of projection thus adopted may be contrary to custom but, considering all conditions and requirements, it is believed the departure from custom is justified.

FIELD SHEETS.

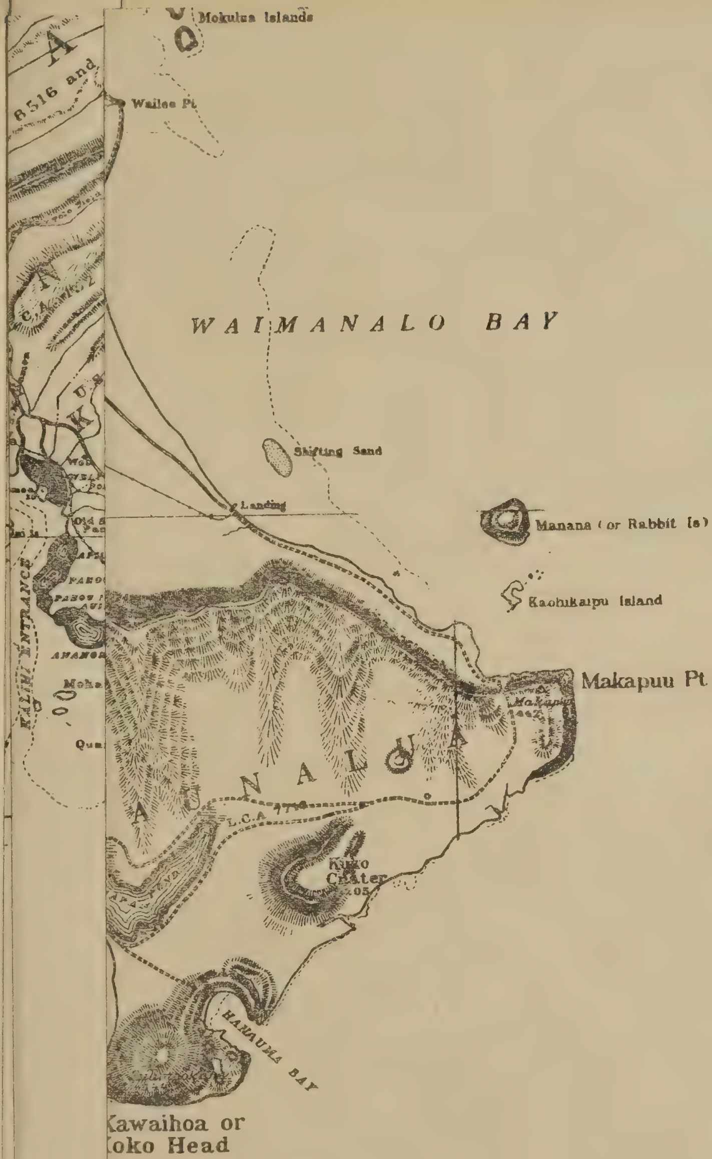
The adoption of field sheets of a uniform size, forming a specified fractional part of the final map is desirable, simplifying the records files in the drafting room. This requires a uniform scale to be used by all parties in the field. In some cases it would have been required the same field sheet to be used by different parties who worked on opposite slopes of a mountain range, the crest of which intersected the field sheet. Thus, in some cases, a field sheet might not have been completed for more than a year. As carried out, a party going into the field was given a control sheet for the territory to be mapped on which was indicated when available the limits of the topography of adjacent territory. The party was then permitted to adopt any size field sheet found most convenient for the particular area being mapped and for the instruments used. In the early period of the survey the field parties were permitted to use one of the several scales larger than 1 : 18,000, as found desirable, but finally the scale of 1:12,000 was adopted for field work. Any disadvantages in the use of field sheets of uniform size would certainly be outweighed by the advantages and probably such field sheets would have been adopted had the survey originally been planned to include the entire island.

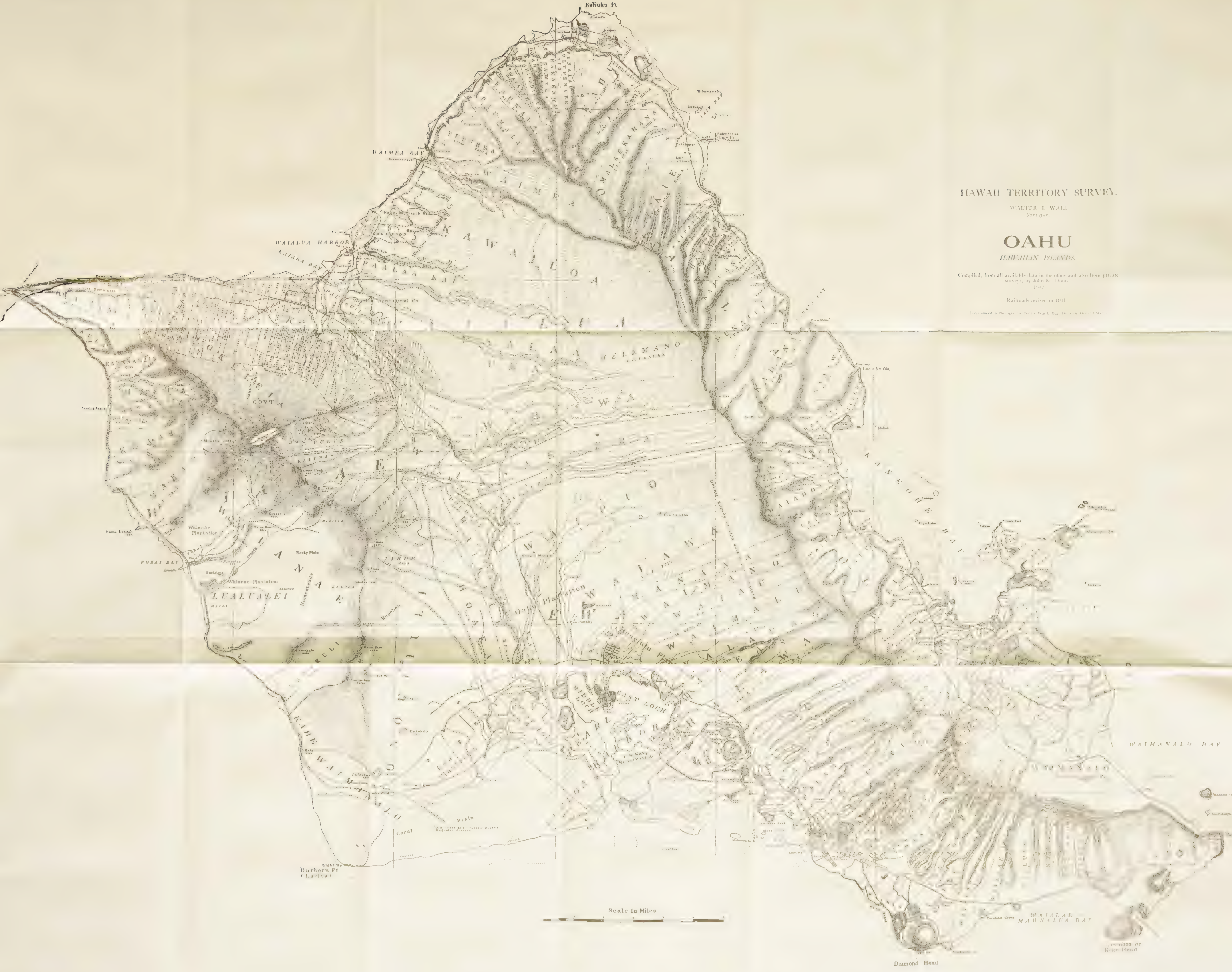
PANTOGRAPHING.

The transfer of the topography on the field sheets by pantographing was necessary on account of the paper and scale used in the field, but should be avoided when practicable because of the liability of failure to transfer some of the details appearing on the field sheets. Photographic reduction when practicable with accuracy is preferable. Especially in wet weather much annoyance occurred by changes in size of the sheets of tracing linen to which the work was finally transferred.

DRAWING PAPER.

Vellum paper was used for field and control sheets. The control sheets to which the field work was transferred in the drafting room maintained their dimensions very well. On some which are more than two years old and which have not been used much on account


Mokulua Islands
8516 and
Wailea Pt
WAIMANALO BAY
Shifting Sand
Landing
Manana (or Rabbit Is)
Kaohikaipu Island
Makapuu Pt
Makapuu
1467
KALIHI ENTRANCE
ANANOE
Moha
Qua
N A L U A
L.C.A.
Koko
Crater
1205
HANAUMA BAY
Kawaihoa or
Koko Head



HAWAII TERRITORY SURVEY.

WALTER E. WALL
Surveyor.

OAHU

HAWAIIAN ISLANDS.

Compiled, from all available data in the office and also from private surveys, by John M. Donn
1902

Railroads revised in 1911

[Reproduced in Photographic Rooms War College Division, General Staff.]

Kahuku Pt
WAIMEA BAY
WAIALUA HARBOR
KAIAKA BAY
PUPUKEA
WAIMEA
KAWAILOA
PAALAA KAI
HELEMANO
MALAEKAHANA
PUNALUU
KANEOHE BAY
Waianae Plantation
POKAI BAY
Rocky Plain
LUALUALEI
MAILI
LIHUE
WAIANAE
WAHIAWA
WAIPIO
WAIAWA
WAIMANO
MANANA
WAIMALU
HALAWA
Oahu Plantation
EWA
EAST LOCH
MIDDLE LOCH
PEARL HARBOR
HONOULIULI
Coral Plain
Barber's Pt
(Laeloa)
Scale in Miles
WAIMANALO BAY
WAIMANALO
WAIALAE
MAUNALUA BAY
Diamond Head
Kawaihoa or
Koko Head

of being partially filled by topography, it is not possible to detect any variation in dimensions. On others much used shrinkage measured one-fiftieth inch. The test described by Lieutenant Besson, of wetting and exposing to the sun, is very severe and not met with in the field. While the paper was subjected to dampness, efforts were made while in use in the field to prevent them from becoming wet by the use of a water-proof covering over the sketching board.

The damp atmosphere at night in the mountains did cause the field sheets to enlarge, but, being held by the thumbtacks, it usually returned to nearly its original dimensions in the morning. Vellum paper becomes brittle with age and then cracks or breaks easily. Its comparative freedom from change when protected from extreme dampness would make it desirable for use as tracing paper from which to make reproductions were it more transparent, so that clear prints could be obtained. The new equipment of Engineer Troops provides celluloid sheets in the reconnaissance equipment, thus furnishing a material not subject to change on exposure to weather.

INSTRUMENTS.

The use of transits and lack of use of plane tables was doubtless due to availability of the instruments at the Engineer Depot from which they were shipped. Transits being a more universal instrument than a plane table, are generally purchased in every Engineering bureau rather than a plane table, which is limited to a special class of work. The equipment of the Engineer companies required the issue of one plane table to each company. Aside from this there was probably limited demand for plane tables in the Engineer Department and therefore there were probably few available for issue for use on the survey of Oahu. The method of plotting the notes and entering all topography in the field by the sketcher is really the plane table method except that angles are read with the transit and plotted by means of a protractor instead of sighting the telescope of the alidade of a plane table upon an object, the ruler of the alidade then determining directly the direction on the field sheets to the position of the object aimed at. In both cases distances are determined by stadia measurements and laid off to scales. The latter method avoids errors of measuring or reading angles and of platting the angles, whereas the former method permits keeping the notes of the traverses, and the adjustment of the traverses or determination in some case of the cause of errors of closure of traverse circuits without running the traverses in the field again. I Company had in its equipment a good plane table and it was extensively used on surveys at Schofield Barracks and vicinity, where the country was well adapted to its use. Its use in the mountains was not favorably considered and it is believed with good reasons. The alidade would certainly have been damaged by becoming entangled in the vines and underbrush in changing stations and would have restricted the use of the hands in climbing steep slopes, whereas the tripod with transit mounted upon it, although burdensome, was at times found useful in climbing. The small mountain transits were best suited to work in the mountains. The plane table board and tripod, presenting a large surface, would interfere with travel along the restricted trails by becoming caught in the vines and brush. In addition to its being cumbersome, it would have been found exhausting by reason of its weight. On each plane table sheet there would be several previously and well determined points for control. The size of field sheet and scale used would have required these points to be very close together had small tables been used, in order to overcome the disadvantages of a large table. The winds in the mountains are usually so strong that in order to maintain a plane table in position it would be necessary to anchor the tripod by some means and in many cases it would be well nigh impossible to do reasonably accurate work. The transit presenting a smaller surface to the action of winds is better suited for use under such conditions.

LACK OF ENGINEER TROOPS.

Lieutenant Besson mentions the need of more Engineer troops in the Hawaiian Department. The supply of Engineers, officers and troops, seems never equal to the demand. For some years the authorized strength of companies of Engineers has been maintained practically at war strength in the endeavor to meet the demand for such troops. The proposed garrison for the Hawaiian Department includes one three-company battalion of Engineers. The decision in this respect was probably governed largely by the probable available supply. Considering the possibility of siege operations in the defense of the naval base, the demands for Engineer troops for demolition, mining, erection of obstacles, laying out and supervision of construction of entrenchments and communications would require more than one battalion, yet there is but one company on the island and whence the other two companies recommended shall be furnished is not clear. Evidently, the increase of the number of Engineer troops by legislation is imperative.

Although the office and field work of the survey has been under the direction and supervision of officers, the map is essentially the work of the enlisted men of the companies. Many persons have been surprised to learn that the enlisted force of the companies can perform such work.

Majs. McDONOUGH and BOND

Corps of Engineers

This is a good article by a young officer who shows that he has a practical grasp of the subject of topographic surveying. He gives a clear picture of the work done on the Oahu survey, the purpose of the work, size of the project, the method of projection, the field work, and finally the proposed method of publication.

DIVISION INTO SHEETS.

The field sheets and the publication sheets are laid out on arithmetic coordinates; thus the publication sheets are exactly 9 by 8 miles, or, in inches, 31.68 by 28.16. The author states that he would have preferred a division on geodetic lines. This is concurred in. Accordingly, a publication sheet on the 1:18,000 scale should preferably be a 10-foot square or a 7-foot 30-inch square. The map being projected geodetically, the division into sheets should conform to the meridians and parallels.

SCALE.

Most of the minor surveys that the Army has been called upon to make seem to have grown naturally, rather than to have resulted from a carefully studied plan, under continuity of control. One of the immediate results of the lack of proper initial advice, and one that is far reaching, is improper scale. The scales which the military actually want are fairly uniform throughout the world, and are well recognized. What the unskilled councils of the military think is wanted is a scale usually much larger.

A map to be used in the saddle must fulfill certain conditions:

1. It should show as large an area as practicable.
2. It must not be larger in size of sheet than can be handled conveniently in the open, when the wind is blowing. This condition limits the size to about 24 inches square, which, in fact, is somewhat larger than most nations employ.
3. The scale must be such as to show details suitable for such tactical operations as marching, the occupation of a position, outposting, camping, etc. Scales smaller than about 1 inch to the mile will not show topography in the detail necessary for these purposes.
4. The map sheet should be approximately equal in its two dimensions.

To fulfill these four conditions then, the sheet must be a rectangle of approximately 15 to 20 minutes of latitude or longitude, the scale about 1 inch to the mile. Such a map is known as a tactical map, and represents, approximately, a day's march of troops along either dimension. Maps of this character are published by each of the military nations.

The military have need of other maps. For strategic studies more area is desired on a single sheet, and at the same time topographic detail can and should, to a great extent, be dispensed with. To satisfy this need an edition on a scale of from 1:100,000 to 1:300,000, is issued by all military nations. In the case in hand it can be stated at the outset that the military authorities will certainly and promptly call for an edition on a single sheet, showing the entire island; the size of the sheet not to exceed about 30 inches square. This will probably result in a map on a half-inch scale, showing Oahu in its relation to adjoining islands of the archipelago. In a country that is densely populated and of not too great an area, there is usually a demand, for certain purposes, chiefly civil, for larger scales. The demand ought usually to be satisfied by a scale not exceeding 1:25,000. The demand for scales larger than this comes, if at all, from the civil administration. Except in unusual cases, the field work should not be executed on a scale larger than this. If maps of certain special areas are required for fortification or other purposes, on a yet larger scale, they are made special orders, the field work being executed on the larger scale only, and reduced in the office for the smaller scale editions.

The military requirements of a tactical or of a strategical map are not more exacting because the area of a place, like Oahu, is small. Hence it is believed that the extra effort expended in the execution of maps *for military purposes* on scales of 1:6,000 or 1:12,000, is wasted, and the same is true, in lesser degree, for the 1:18,000 scale. The expense of and time required for making maps varies roughly with the total area of the field sheets, being but little dependent on the scale. Thus the cost of and the time required for mapping a given area on a 2-inch scale will be very nearly four times that of mapping the same area on a 1 inch scale. If there be need of maps for both civil and military purposes, and if the cost of the mapping is to come, ultimately, from the same treasury (United States) it may be economy on the part of the General Government to have the field work executed at the outset on a scale that will be suitable for all subsequent purposes, as well as for the immediate need. The foregoing is the only justification for the military spending time and money in mapping areas on scales larger than those known to be adequate to military needs.

The Engineer Department should always be well represented in the preliminary councils that decide upon the details of survey execution. Our Engineer troops have very often been directed to execute maps on scales that consume greatly too much time and money. The authorities become impatient for the completion of the task, and the blame for any delay is laid on the personnel doing the work. In the case under discussion the writers would have advised that the field work be executed on a scale not exceeding about 1:25,000; the largest scale edition of the map to be the same. For such a map there is hardly a necessity for enlargement of the field scale over that employed in publication. The writers would also advise the publication of 1 inch and ½ inch editions. The field work having once been executed on an adequate scale, the issue of subsequent smaller scale editions is a matter of office work only, involving comparatively little additional labor and expense.

Under the conditions which obtained on this survey, with continuity of supervision, and four or five officers attached to the Engineer company, the work should have been completed in about a year. Those areas whose topography is exceedingly rough should have been mapped by sketching and not by precise methods.

PROJECTION SHEETS.

Unchangeable board, as suggested by the author, is much more satisfactory for projection sheets than is vellum. These sheets should be, as nearly as possible, proof against moisture and temperature changes, and should last indefinitely. They are an important item of the permanent record of the survey. They are subject to much handling and innumerable erasures. Vellum does not well withstand such treatment. Vellum, however, does very well for field sheets. It is tough, will stand the usage to which a field sheet is subjected, and is not easily destroyed by rain, etc. Transparency is a desirable feature in a field sheet, both for tracing survey control from the projection sheet at the outset and later for transferring to the same projection sheet the topographic detail of the completed field sheet. Celluloid also is suitable for field sheets. For a scale as large as 1:18,000 the writers would have executed the field sheets on the same scale. These could then have been traced directly by the interposition of carbon paper on the projection sheets, thus saving much time and expense.

FIELD SHEETS.

The author's remarks concerning the field sheets evidently are made feelingly. Each sheet should be self-identifying at a glance, and should bear the topographer's name. The writers suggest that these field sheets should be filed so as to be instantly available. They are the original record, not only of the detailed topography, but of the responsibility for the work. Whenever in the future the accuracy of topographic detail anywhere in Oahu is challenged, the field sheets will at once be demanded. They should therefore be carefully preserved. They should, however, be intelligently filed, not buried.

The writers believe that the limits of topography shown on any field sheet should follow landmarks for boundaries rather than arbitrary lines ruled on the sheet at fixed distances. Topographers in charge of adjacent field parties meet not on paper dividing lines, but on roads, streams, and the like. The first of two topographers to map a common meeting line should give his data to the other to the end that an exact meeting be insured.

The author says: ''The United States Geological Survey sheets are laid out by the use of geodetic coordinates, while the Engineer sheets are laid out by arithmetical coordinates. The latter method was chosen, probably, because it was believed to be not practicable to teach the enlisted men geodetic work. By requiring the officers to work out all the positions and reduce them to arithmetical coordinates in inches, the enlisted man may easily plot the points with reference to his 10-inch squares. The man doing the field work therefore never gets beyond plain surveying. This system has led to much extra work and inaccuracies that have had to be corrected. * * * The system of geodetic coordinates and the construction of a projection for each field sheet can easily be taught the enlisted man.'' The writers are not surprised that considerable inaccuracy did result from this combination of control. We do not admit that it is practicable for enlisted men to construct geodetic projections in the field. Assuming that the man can be taught *how* to do it, it is still too much to expect that enlisted men as a class will have the necessary instrumental delicacy to lay out a projection that is sufficiently accurate. This task should properly be executed in the office by the best talent, and under the best conditions. We believe that the best method of providing field sheets is as follows: the projection sheet should be laid out in the office with the necessary meridians and parallels drawn upon it; upon these graticules is then laid out by geodetic coordinates all the control available. Such control will be in the form of primary triangulation, secondary or tertiary triangulation, any traverses that have been made in the field, accepted traverses from other sources, etc. The field sheets are traced on transparent vellum directly from the projection sheet, thus showing the graticules and all the control of the projection sheet which lies within the area of the field sheet. The field sheet is thus a true reproduction of a portion of the projection sheet. On this field sheet the topographer fills in the detail without reference to any arithmetical coordinates. The topographic detail having been completed on the field sheet is then traced upon the projection sheet by the use of hardwood points and carbon paper. For the tracing, the field sheet is lined up over the projection sheet by means of the graticules on each, rather than by the superposition of control points.

Field sheets should always be inked in colors. This requires no extra time to execute, yet the sheet is much more intelligible, not only to the topographer himself, but to the draftsman in the office.

TRIGONOMETRIC CONTROL.

The author states: ''The traverses are controlled by adjustment on triangulation and subtriangulation stations and determining by trigonometric methods the positions of actual points. The amount and character of the control is governed by the judgment of the officer in charge of the detachment. For the most accurate results an adjusted quadrilateral is established on the main triangulation as a base, or upon parts of other adjusted quadrilaterals.'' The writers do not gather from a reading of the article just how much control was left to the judgment of ''the officer in charge of the detachment.'' We believe, however, that it is a mistake to make him responsible for important control. Control and filling-in work are usually mutually incompatible, in the same party. They should be executed at different times and generally by different parties. The necessity of providing control greatly retards the work of filling-in. Traverse control between tertiary stations is, of course, the duty of the topographer, and subject to his judgment, under prescribed rules, but control of an order higher than this should generally be provided by the central organization. It is a fundamental principle of surveying, particularly of precise and organized surveying, that prior to sending out filling-in parties adequate primary and secondary control shall have been provided. The object of this provision is that the control shall be comprehensive, executed by the best talent under the immediate direction of the responsible head of the survey organization, and hence independent of the vagaries in skill and judgment of the local topographers. A proper balance between primary and local control is the secret of success.

REPRODUCTION.

The proposition to publish black topographic maps, lettered throughout in red, we think, would have proved very unsatisfactory if carried out. The writers firmly believe that a 1 inch edition of this survey should be lithographed in colors. The total expense for the small area involved will be inconsiderable. The inch edition will be in very great demand, and in a short time the call for a colored lithograph map, preferably from an engraving, will be imperative. The survey is understood to be an excellent piece of accurate work, calculated to reflect much credit on those who executed it. This being so its publication should be in a dress commensurate with its accuracy and its military importance. The map should be engraved and lithographed at once. If we read the article correctly, the author speaks of the probability of issuing lithographed sheets, 8 by 9 inches. These sheets would be very small, and the number of them bothersome. Why not combine four of them in one when engraving on the 1 inch scale? This would give sheets 16 by 18 inches, a very convenient size.

RECORDS OF THE SURVEY.

We would like to hear the author say how he has made the permanent record of the survey. A survey consists of three parts: (1) The physical monuments; (2) The written record of the relations of these monuments (geodetic coordinates, azimuths, distances, elevations, local descriptions of monuments, with sketches, etc.); and (3) The map. If any of these three elements be lacking, lost or hopelessly buried, the survey is incomplete, and the efforts have, in greater or less measure, been wasted.

The lieutenant speaks of the gross carelessness of the non-commissioned topographer, who omits the identifying graticules from his field sheets. What shall be said of the higher sin on our part, in omitting to file, clearly and intelligibly, the record; who leave ephemeral or even no marks on the stations? Many occasions will arise for the reoccupation of the primary and tertiary stations after the present personnel have departed. Is the record such that, ten years from now, it will guide your successor surely to the monument, and when he reaches the place will the monument be there?

See that the marks are permanent; that they can not be removed by carelessness or malice, nor destroyed by the elements.

Maj. C. O. SHERRILL

Corps of Engineers

The interesting description of the methods used in mapping Oahu Island points to a line of work for Engineer Battalions that would be of immense value to the Government as well as of great instructional service to the officers and enlisted men engaged. This is to assign to Engineer companies the duty of mapping areas of strategic value. This idea was recently mentioned by Capt. G. R. Spalding in his pamphlet, entitled ''The Engineer Officer and the Mobile Army.'' He shows the absurd results obtained by attempting to use unskilled men to fill in the topographic details of a geological sheet, on which only a minute amount of detail is shown.

There could certainly be no more valuable work done for the country in time of peace or war than this of making a systematic and thorough military map, which should be placed in the hands of the Engineer Department to be executed by Engineer troops or the civilian survey forces now operating under the department. A fact not generally appreciated in this connection by the public at large is the large forces of surveyors employed throughout the country under the Engineer district officers.

A complete military map has of necessity such a considerable amount of topographical detail not given on geological maps, as to make them of the greatest value commercially as well as for military purposes. To grasp this difference between a military map and a geological map one need only compare the official German maps of the vicinity of Metz with those of the Geological Survey. This is in no manner a disparagement of the Geological Survey maps, for they are excellent for the purpose for which they are made, viz, the exposition of geological resources of the country represented. Where these maps exist, they could be advantageously used for the framework of the military maps.

The extent of the work involved in this mapping of the United States territory is so enormous that it would require several generations for completion and hence the strategic areas on the boundaries should be covered first.

If the Government were brought to realize that Engineer troops could be constantly employed in this way, it would probably lead to an increase in the number of battalions in the interest of this most important commercial and military work. The country would in this way have available for war a large trained Engineer force whose upkeep in time of peace would be more than repaid by the value commercially of their map output. Such Topographic Engineer Battalions could be sent in rotation for station at garrisons and to maneuver camps to acquire the necessary instruction in the other duties of Engineer troops.

The subject of a military reserve is at this time receiving a great deal of attention and here is a simple and highly economical means of providing one for this branch of technical troops that fulfills the requirements admirably, for if the people of the country felt that troops during peace were turning out valuable commercial work the objection to a larger military force would disappear.

Capt. FREDERICK B. DOWNING

Corps of Engineers

The value of the map described in the "Military Survey of Oahu" can only be guessed from its description. It will be proven by use.

The description, however, brings out several points and suggests others which are noted as follows:

FIRST: TIME AND EXPENSE.

Four years and a half of practically continuous work—by a large part of one company of Engineers was spent in the field, and during this long period an office force was also constantly employed. The expense could hardly be determined. But as big as it is, it would be pardonable if there were no cheaper method of getting the same map. Neither the time nor the expense, though, can be charged against those that did the work. The trouble was with the system, which originates with higher authority, and which by frequent changes tends not to train specialists but to make Jacks of all trades.

The job, if done by the military, should have been assigned to one group—a company or a detachment with a proper quota of officers—and they should have been kept with it until its completion.

SECOND: THE SCALE ADOPTED.

Army regulations prescribe that military maps shall be made in accordance to a uniform system of scales. The scales specified are: 1 inch, 3 inches, 6 inches, and 12 inches to the mile. This is rather an elaborate system, and it might better be simplified.

But it is well to stick to some system. The Oahu map is 3½ inches to the mile. It is a nondescript among our maps. One of the Army Regulation scales should have been adopted.

For general service, to supply military needs, the 1 inch scale with 20-foot contours gives an excellent map. It is, perhaps, the scale on which all of our general maps should be drawn. Its suitability is attested by the satisfactory use at maneuvers of the U. S. Geological Survey charts, whose scale is approximately an inch to the mile.

The 3-inch scale makes a map that is bulky and unwieldy. It does not show the so-called "military features," which are, in truth, only topography, in detail sufficiently greater than is shown by the inch map to warrant its preferment. The inch map is the one that an officer in the field—general or subaltern—will work with.

Position sketch is an expression that is nearly trite. Lines of battle are as long as 60 miles. Imagine a position sketch for such a line!

Delineations of forts, redoubts, siege operations and similar military works related to permanent fortifications are hardly maps. They are more properly surveys. And they should be instrumentally accurate. Appropriate scales for such surveys are suggested as 100 feet to the inch, 300 feet to the inch, 1,000 feet to the inch.

THIRD: THE BALANCE BETWEEN FIELD AND OFFICE WORK.

The character of the office work on the Oahu map does not balance with that of the field work. The balance is not to the credit of the office.

The work in the field appears to have been done very laboriously—and generally with due regard to accuracy. But, in spite of the ruggedness of the country, the field sheets should show the same contour interval as do the finished maps. Otherwise, the temptation of an artistic eye in the office, or of a slovenly man in the field may prove too great, and the map will be falsified. It is well to avoid such risks.

The usefulness of the plane table is not exaggerated in the description of the survey. Underscore therein these words, "The plane table * * * method was not given a fair test."

But although charged with the above criticisms, the balance is still in favor of the field work.

"Often the drafting room has been ready for a field sheet before it was finished." But the draftsmen were not required to waste time in making conventional signs.

The mere word "conventional" has the force of agreed, stipulated. Conventional signs in mapping were in common use long before the date of War Department Document 418. Moreover, the instruction for their use in the various service manuals is of the nature of orders. It would have been better to water-line the water areas on the map of Oahu.

The care with which the lettering of a map is done, its quality and its uniformity, is not infrequently a fair indication of the reliability of a map. The indifference of the lettering described for the Oahu map unfortunately tends to discredit not only the general character of the office work, but also the precision of the laborious work that was done in the field. The better the lettering, the better the map, is true; as true as, the better the map, the better the lettering should be. It appears that a more even balance might well have been kept between the field and office work.

But in the end, the proof of the map will be its use.

Final Discussion

Lieut. F. S. Besson
Corps of Engineers

This article has been an attempt to have recorded some things that would be of value to future inexperienced young officers.

It has been a pleasure for an officer young in the service to see what conscientious, accurate work enlisted men do. I found that old soldiers knew a lot more about their part of the work than I did about my part of it.

I wish I had had available the discussions of this article three years ago, when I was first notified that I should assist in the Military Survey of Oahu.

It is to be regretted that the discussions were not written in 1908, prior to the arrival of Company A in Honolulu.

The discussions have brought forward the elements that should be considered in organizing a survey. In particular, the one written by Majors McDonough and Bond shows an acute discernment of pertinent points.

This survey is another Army survey that grew naturally and without proper initial advice. One of the officers with the company which started the work stated that upon his arrival, "It was found that there was no detailed instructions for the survey, except that it seemed to be understood that the survey was indicated in Major Haan's project. There was no copy of the project available."

I hope I have not given the impression of hypercritizing the work that has been and is being done by the Engineer troops on Oahu. The field work has been most thorough and will stand favorable comparison with the best that the Corps has ever done. Never in the past and probably never in the future will there be another prospective battle area so well mapped. Major Lytle Brown will never see two armies on Oahu, sitting, waiting, and sleeping, while the Engineers out in front are preparing the maps. Good work has been done notwithstanding the many difficulties that had to be overcome in order to coordinate the various elements making up a complete survey.

Military map making and reproduction in our Army should be superintended by a centralized organization having absolute responsibility. Captain Spalding's recommendation is, That an Engineer officer be placed in charge of the mapping and reproduction work of the Military Information Division of the General Staff.

I wish to close my remarks with what seems to me to be of vital importance:

I do not know when or how the Military Map of Oahu will be reproduced. The United States Geological Survey have prepared from our work, for their engravers, a map of Oahu, scale 1:62,500,

V. I. 40′. At this point the work was stopped by the War Department for military reasons. For the same reasons the War Department and the United States Geological Survey should get together and energetically push the reproduction to completion. The making of this map should not be blocked, the public distribution of it should be.

A small but very important change should be made in the photographic copies furnished the engravers. The scale should be 1 inch to 1 mile—that is, 1:63,360 instead of 1:62,500 V. I. of 50′ would be better than V. I. 40′, but the change is not important enough to warrant the cost.

After the publication of this 1 inch to 1 mile map the original map, scale 1 inch to 1,500 feet, should be classed with the other special scale maps made by the Engineer company. If we have a good 1 inch to 1 mile map, copies of the 1 inch to 1,500-foot map, sufficient for all purposes should be made from brown print negatives taken from the original tracings, and the latter be safely stored.

The 1 inch to 1 mile map, V. I. 40′, should be engraved in one sheet in colors.

A one-sheet map to this scale will not be of excessive size. A map entire in one piece will be valuable in many ways, and when sectional sheets are desired the map may be cut up by one's self, so that the division lines do not pass right through the position one wishes to study.

Map Making in Connection with Land Defense for Seacoast Fortifications and Seacoast Cities

BY

Capt. LEWIS H. WATKINS
Corps of Engineers

INTRODUCTION.

In this paper an attempt will be made to record, in as brief a manner as possible, the practical information gained by approximately four and one-half years of continuous work in constructing maps for land defense projects for seacoast fortifications and seacoast cities. It is not the intention of this paper to discuss the theoretical problem connected with map making, but rather to explain what the work is for and the methods found most expedient for this class of work. The intention is to record such information, gained by experience, that may be of some assistance to one who has been detailed for this work and has had no previous experience in work of this nature.

THE LAND DEFENSE PROJECT.

In order that the reader may understand clearly what maps are needed for a project of this kind, a brief explanation of one of these projects is necessary. For the defense of our seacoast frontier, the frontier is divided into numerous sectors, and each sector has its own plans for defense. The troops provided for each sector are to have such strength, organization, arms and equipment, and are to be provided with such field fortifications that they will be able to hold an invader in check, and prevent him from capturing any seacoast fort or city or other important point until reinforcements can be sent from another or central supporting point. It is with the plans of defense of one of these sectors that the reader is particularly concerned.

The troops engaged in the defense of each sector may be divided into three general heads: First, the Coast Guard or Army, to be located at a central point, to be prepared to meet the enemy on any possible route of approach, and to give reinforcements to minor organizations defending important points within the sector; second, the Supports, to occupy a defensive line 5 to 10 miles distant from the seacoast fort or other important point, and to protect the same from an invader until reinforcements can be sent from the Coast Guard; third, the Coast Artillery Reserves, to occupy a defensive line in the immediate vicinity of seacoast forts and important points, and to protect them from raids until reinforcements can be sent from the Supports.

It is not practicable for these troops to be organized and mobilized in time of peace. The time for the execution of such a scheme of defense would be so short after the declaration of war that it would most probably be a failure unless well prepared plans for its immediate execution were prepared in advance. It is the preparation of these plans, and the arrangement for their immediate execution at the outbreak of war that is called a land defense project.

It becomes apparent that a land defense project should cover the following points:

1. The strength, organization, arms and equipment of each body of troops to be engaged in the sector of defense.
2. Their mobilization.
3. Routes over which they are to maneuver.
4. Lines of communication and supplies.
5. Points favorable for offense and defense on all routes of approach.
6. The location of field fortifications where necessary, and complete plans for their preparation.
7. The location of camp sites, and complete plans for their preparation.
8. Plans for supplying the troops both while in camp and while in the field or in the fortification. Water supply is a very important item under this head.

BY WHOM DRAWN UP.

These projects are drawn up by a board of officers appointed for that purpose. After securing all the data and information possible concerning the sector to be defended, and while considering the general scheme of land defense for the seacoast frontier, the board draws up a general scheme for the land defense for that sector. This general scheme shows the number and organization of troops assigned to the sector for its defense, the concentration and mobilization of these troops, the probable routes over which an invader may approach, the important points to be defended, the general location and plan for the defensive fortified lines and troops to be assigned to them, the general locations of camp sites, the probable lines for communication and supplies, the probable source for water supply, etc. As a rule, on account of the lack of good and suitable military maps, the board can do nothing more than draw up a rough outline of the project. On that account, an Engineer officer, with a detail of troops, is detailed to construct the maps and draw up the plans in detail. He follows the instructions of the board and the general plans drawn up by them and, when the work is completed, submits it to the board.

MAPS AND PLANS NEEDED FOR THE PROJECT.

From the outline above it can be readily seen what maps will be needed for the project. Requirement (1) can not be determined until detailed information of the terrain has been obtained. For mobilization, accurate information concerning railroads, water lines, and highways must be secured. A map of all possible routes of approach of an invader must be secured. This must be of sufficient detail to enable the commander of the Coast Guard, who may not be familiar with the territory, to operate with advantage against the enemy, to select lines of communications and supplies, and to select favorable points for offense and defense.

It is contemplated that the Supports occupy a defensive line, made sufficiently strong by field fortifications, to hold the invader in check, at least until reinforcements may be sent from the Coast Guard. It is not practicable to construct these field fortifications in time of peace, hence plans, complete in every detail, must be prepared for these fortifications. These plans must show not only the location, size, and shape of every redoubt, trench, entanglement, etc., of the fortifications, but also the area and nature of the foreground to be cleared, the line of communications in the rear, the water supply, and in fact everything for a strong defensive line. Moreover, it is very probable that the troops that will be available for this defense will, in a great part, be recruits who will be in great need of instruction in the arts of war.

It will not be advisable to take these recruits from this instruction to prepare these defensive lines. In that case the work of preparation of these defensive lines may, in a great part, be done by contract with civilian labor. That, of course, will depend, to a great extent, upon the location of the sector to be defended. At any rate, it is evident that these plans should show the number of men necessary to complete the work within the prescribed time, the best organization of the working parties for each section, the material to be used and its source of supply, and the probable cost of construction.

Similar plans must be prepared for the fortifications to be used by the Coast Artillery Reserves. Plans as complete in detail for the location and preparation of all the camp sites to be used by the troops must be prepared. Plans for supplying the troops in these camps should be prepared. This may call for plans for the construction of wharves, roads, pipe lines, etc.

There is a considerable area between the point defended by the Supports and their defensive line. Detailed information of the terrain in this territory is of great importance to the Supports.

CLASSES OF MAPS REQUIRED.

In deciding upon the class of map to be used for a military purpose, there are four very important considerations to be fulfilled. They are as follows:

1. Information to be shown. This deals not only with the details shown, but also with the accuracy with which they are located.
2. Time for construction or obtaining same.
3. Cost.
4. Convenience in handling.

To fulfill the first requirement, so far as this project is concerned, a map of the entire territory involved showing every minor detail and inequality of the terrain would be desirable. Such a map, however, would as a rule conflict with the other three requirements. The time that may be used for the completion of one of these projects is very limited. It will be impossible to procure such a map, but the maps used must be constructed by details of such troops, as a rule Engineer companies, as are available. To construct such a map under these conditions would require a very long time. Moreover, the cost of the construction of such a map would not be warranted by the purposes for which it is to be used. Furthermore, such a map would be very large and unwieldy. In this respect, it must be remembered that the amount of detail that may be shown on a map in a legible form varies by a ratio less than the square of the scale. On the other hand, experience has shown that where the accuracy and detail of the map are compatible with the scale used, the time and cost of construction vary by a ratio greater than the square of the scale.

The purpose for which the map would be used should be considered, and the above requirements should be fulfilled as best as can be done under the given conditions. The maps, as a rule, will have to be constructed by troops and within a short time. Under these conditions three classes of maps will be called for. They are as follows:

I. Maps for the location and plans for the defensive lines, for the camp sites, and, where necessary, for the plans for subsistence and water supply. These maps should be on a scale of about 6 inches to the mile with contour interval of 10 feet. This is the military scale. It is considered that, for practical purposes, a scale of 1 inch to 1,000 feet would be much better. In drawing up the plans, a scale in feet will be found much more convenient than one in miles. The plans for redoubts, pipe lines, roads, and wharves, should be on a scale of 1 inch to 200 feet. The accuracy of these maps should be about one in five thousand. To obtain this accuracy, especially if the defensive line be long, it will be necessary to establish a triangulation system, and fill in all details with a transit and stadia.

II. Maps of the territory between the defensive line and the point or points defended. This should be constructed on a scale of 3 inches to 1 mile and 20-foot contour intervals. Its accuracy should be about one in one thousand. Such a map may be constructed by running traverses with transit and stadia over all important roads for control points, and filling in details of intervening territory with reconnaissance sketching cases.

III. Maps of the territory in front of the defensive lines containing all available routes of approach of an invader from the seacoast frontier. These maps should be constructed on a scale of 3 inches to 1 mile with 20-foot contour intervals, and have an accuracy of about one in five hundred. Such a map may be obtained by running a traverse over the route in question by means of a transit and stadia, and filling in the intervening roads and territory, where necessary, with reconnaissance sketching cases.

ORDER IN WHICH THE WORK IS EXECUTED.

When this work is undertaken by the Engineer officer detailed as mentioned above, that part of the project which will be first needed in time of war will be done first, and the project enlarged as each portion is completed. The plans for the fortified lines, camp sites, water supply, etc., will be the part to be done first. The area between the defensive fortified lines and the points to be defended will be done second, and the possible routes over which an invader may approach will then be mapped. This is the order in which the classes of maps needed for the project are given above. In the explanation of the construction of maps which follows, each class of maps which corresponds with each portion of the work will be taken up in the same order and discussed in detail.

CONSTRUCTION OF MAPS.

The construction of these maps will necessitate the division of the company into small detachments which will be stationed in camp at points away from the company and must act more or less independently. In the discussion which follows, a suitable organization for these detachments for each class of maps will be given. This will include the number of men necessary, the duties of each, the camp equipment, and the transportation and animals required.

In the construction of maps, certain well defined steps are, in general, necessary. Those steps are as follows:

1. The location of control points.
2. Making the field sketch.
3. Transfer of the field sketch to the field sheet.
4. Transfer of the field sheet to the general or office map.

For each class of maps, each of these steps will be taken up in order and discussed in detail.

CLASS I. MAPS FOR THE DEFENSIVE LINE, CAMP SITES, ETC. ORGANIZATION OF FIELD DETACHMENT.

The following men and equipment are desirable for a field detachment in constructing this class of maps.

Personnel.

Officer in charge of party	1
Mess sergeant (non-commissioned officer)	1
Cook (private)	1
Assistant cook (private)	1
Teamster (private)	1
Draftsman (private or non-commissioned officer)	1
Two field parties (one non-commissioned officer and six men for each party)	14
Hospital Corps (one private)	1

Total, one commissioned officer and twenty enlisted men.

Camp Equipment.

Hospital tents (1 kitchen, 1 drafting tent)	2
Wall tents (1 for commissioned officer)	1
Conical tents (5 for men, and 2 for stables)	7
The necessary kitchen utensils.	

Transportation.

Escort wagon	1
Mules for escort wagon	4
Saddle horses	2

The above is given as a minimum for ordinary conditions. Should the territory being mapped be wooded or very rough, the field parties should be increased. Moreover, as this work is very trying on the men, it may be expected that two or three will be on the sick list. Provision should be made for those conditions.

LOCATION OF CONTROL POINTS.

Where it is necessary to map an area that has a greater dimension than 2 miles, the primary control points should be located horizontally by triangulation. If the area has a greater dimension than 10 or 15 miles, both primary and secondary triangulation stations should be used. In this classification of triangulation stations, the primary stations are those that should be located by quadrilaterals, and the secondary stations those that may be located by simple triangles. All secondary triangulation stations can be located vertically with sufficient accuracy for this work by means of vertical angles. For the vertical location of primary triangulation stations a Dumpy level should be used.

In deciding upon the number and location of triangulation stations, the purpose for which they are to be used must be considered. The primary function of the primary triangulation stations is to serve as control points for the secondary stations. They should also be available for control points for the traverses run in making the field sketches. The only purpose of the secondary triangulation stations is to serve as control points for these traverses. It has been found by experience that traverses, run between control points not over 2 miles apart, can be plotted with sufficient accuracy by means of an accurate protractor and scale. If the control points be much farther apart than 2 miles, it will be advisable to plot the traverse stations by means of rectangular coordinates. The reduction of the traverse to rectangular coordinates is a very laborious task and should be avoided if possible. The primary stations should be located about 10 to 15 miles apart. They must be so located as to form a good quadrilateral in the primary system, and at the same time must serve as good control points for the secondary triangulation system. The secondary triangulation stations should be located about every 2 miles apart on the lines over which traverses will be run. Before locating any of the stations the most convenient routes over which traverses may be run should be determined and the triangulation systems be designed for that purpose. If this precaution be not taken, it may sometimes be necessary to locate additional secondary triangulation stations, or run traverses over very inconvenient routes, either of which will involve much unnecessary labor and loss of time. For the same reason, these secondary triangulation stations should be located, if possible, at the most accessible and convenient points of the traverse lines.

It will be advisable, before beginning this triangulation work, to consult all offices of the territory or other possible sources for maps or triangulation data for the territory to be mapped. As a rule, maps which will serve as excellent charts for laying out the general scheme of the work can be obtained. It will sometimes happen that a triangulation system for the territory has already been established, which may be used for the primary triangulation system. Such triangulation data must not be used without checking, for, in using such data, errors have often been discovered, due to errors in the office from which the data was obtained, to mistakes in copying same, to mistakes in selecting the true mark of the station, or due to the fact that the original mark has been lost and a second one substituted for it.

Before any traverses are run a sufficient number of control points should first be determined to fix the ends of the traverses. This is necessary for two reasons: First, the traverses can not be definitely fixed until their ends are located, and should some time intervene between the running of the traverses and their final location on the map, the circumstances of the running of the traverse will be forgotten. It will then be more difficult to detect an error in the traverse than it would have been had the traverse been checked immediately after it was run. Second, the horizontal angles measured and recorded in running the traverses should be measured from the true north. If this be done, the orientation of the instrument can be roughly checked at any time by the magnetic needle, and the transfer of the field sketch to the field sheet will be much easier. Moreover, it is very important that all data and information used in the construction of the map be filed in a systematic manner, as part of the records of the construction of the map. If all measured angles of the traverses are taken from a fixed bearing these records will be very easily interpreted. The importance of keeping a file of all data and information used in the construction of maps in a systematic and easily interpreted manner is not fully appreciated until one has had two or three years' experience in map making. All field work must be adjusted to become a part of the map. If the data used in its construction be lost or not capable of being interpreted, this adjustment can not be made. It will then become necessary to spend considerable time and labor in determining its location on the general map, or else, do part of or all of the work over. In compiling the general map, it may sometimes appear that part of the construction of the field maps was very poor, whereas the fault was not in the actual construction of the field maps, but in the records kept of same. The ordinary large company transit is sufficiently accurate for this work. When the location of the (a control) station is decided upon, a mark, usually a strong stake or section of pipe will be driven into and flush with the ground. A target will be placed over this mark. The most satisfactory target is an ordinary pole about 12 feet long with white and red flags, the white at the top and the red underneath. This target is held up by wire guys. It can easily be set up and taken down and should never be blown down. The height of the junction of the red and white flags above the mark of the station should be measured and recorded, for this is the part of the target to be used in measuring the vertical angles.

Both horizontal and vertical angles at every station are measured, and the determination of the location of the stations on the general map computed from these. The horizontal location of these stations is reduced to rectangular coordinates with respect to some fixed point or triangulation station. A complete record of all this data should be kept in a note book, labeled Triangulation Book, Section ——. One page or more should be assigned to each station, and a suitable index for the book made. These records should contain the name and class of the station, a description of the station and its general location, a trigonometric diagram showing how it was determined, the measured and adjusted angles, and length of the sides of the trigonometric figure, the logarithms of same, the azimuth to all adjacent stations, its rectangular coordinates, its elevation above datum plane, the height of target at the station, and the height of the instrument when set at the station for measuring said angles. This data should all be arranged in a systematic manner.

In addition to the above, where it is necessary to measure base lines for the triangulation stations, the record of these measurements should be entered in this book.

THE FIELD SKETCHES.

Mention has already been made of the number of men used in a field party. The division of their duties is as follows:

1 sketcher, to have charge of the party. He should be a reliable non-commissioned officer instructed in this duty.

1 transitman, to take all observations with the transit.

1 recorder, to record all observations and compute horizontal distances and elevations.

1 front rodsman, to establish traverse stations. This should preferably be a man of more or less experience in the work.

1 rear rodsman, to give rear sights and hold rod for observations along the line of traverse.

2 side rodmen, one to carry rod for observations on each side.

As stated above, if the traverse be run through woods, it will be very desirable to have extra men with machetes and axes to clear the line of traverse and line of sights.

INSTRUMENTS TO BE USED FOR TRAVERSE.

The following instruments are necessary for this work:

1 transit.
1 sketching board.
1 protractor.
1 scale.
1 stadia computer.
4 stadia rods.
4 machetes (one for each rodman).
1 hatchet (for front rodsman).

The best transit for this work is the large engineer transit. Good work can be done with the mountain transit, but, while it is convenient to carry on account of its light weight, it is not as satisfactory as the large transit on account of loss of magnifying power and on account of the fact that it becomes very unsteady in a moderate breeze.

The best sketching board for this work is the one furnished the Engineer companies. It has an alidade and a tripod. Upon this board, cross section paper should be pasted. The lines of this cross section paper should point to true north and south, east and west, while the magnetic needle points to magnetic north. Over this cross-section paper, a sheet of vellum paper is fastened with thumb-tacks, and the sketch is placed on this paper.

The best protractor is a full circle paper protractor not over 6 inches in diameter, and should have an arm extension on one side of about 4 inches. This protractor is slipped under the vellum paper with its center at the station at which the sketcher is working, and oriented by means of the lines on the cross-section paper and fastened by its arm with thumb-tacks. A ready means is thus provided for any angle to be plotted from that station.

The scale should serve both as a scale and a straight-edge. A 6-inch boxwood scale is excellent.

Cox's circular stadia computer is excellent for this work.

The stadia rods should be 14 or, better, 16-foot rods.

The plane table is not satisfactory for this work, except possibly for small areas, such as redoubt locations, which are constructed on a scale of 200 feet to 1 inch. Maps made with the plane table alone are less accurate, slower in construction, and more difficult to check and adjust than those made with the transit and sketching board explained above.

RUNNING THE TRAVERSE.

In running the traverse the transit man does all the work with the transit and assists the sketcher in locating stations for the traverse and in directing side rodmen. He calls off the distances and vertical angles to the recorder. The recorder enters these in the transit book, with necessary remarks, computes the horizontal distances, differences of elevation, and elevations of all points upon which observations were taken and enters them in a systematic form in the book. The sketcher has charge of the entire party. He receives the data mentioned above from the recorder, locates the points on the sketch, and plots in all details, including contours, while in the field. Upon returning to camp after each day's work, the sketch made should be inked. If this is not done, very often the pencil lines become very dim or obliterated. Moreover, these sketches should later be filed to become part of the record of the construction of the map.

TRANSFER OF THE FIELD SKETCH TO THE FIELD SHEET.

When the field sketch has been run from one control station to another or is completed, it is transferred to the field sheet. One draftsman can do this work for two field parties. He should have his drafting tent equipped as follows:

1 drafting table 3½ by 6 feet, or larger.
White paper as cover for same to form white background.
1 steel straight-edge, 3 feet. It is desirable that this have a scale graduated to 1-100 inch.
1 boxwood scale, 1 foot, graduated to 1-100 inch.
1 accurate steel full circle protractor, arm about 8 inches.
1 set drawing instruments.
The necessary ink, pens, etc. (assortment of colored ink).
1 roll vellum paper, 36-inch.
3 tin tubes, 36-inch.
Cross-section paper, 20-inch (divided to 1-10 inch).

The best paper to use for the field sheet is vellum paper. As it is semi-transparent, the field sketch can very easily be transferred to it. This paper is less affected by changes of weather than any other. If it contracts or expands, it can be dampened and tacked down to scale and dried to the proper size. The best size for these sheets is about 20 by 20 inches. The edges of the sheet should be rectangular coordinates of the general system for the map, and their number written on them. This furnishes a ready means of transferring the sheet to the general map. The data for the control points obtained by triangulation are plotted on the sheet. When the field sketch is turned in, the line of traverse is plotted between control points by polar coordinates. Cross-section paper placed under the sheet provides meridian lines. The stations of the traverse are then adjusted to fit the control points, provided the error is not too great. If the error be too great, either horizontally or vertically, the line of the traverse must be re-run, or the error must be found. The most probable errors in the order in which they are likely to occur are as follows: 200′ or 100′ error in distance, 5° error in vertical angle, 5° error in horizontal angle, 1° or 2° error in either of these angles. Other errors are not so common.

When the stations have been properly adjusted both horizontally and vertically, the field sketch is placed under the field sheet, and the sketch made from each traverse station adjusted as it is transferred to the field sheet.

After the field sheet has been filled, it should be carefully compared with the sketches to see that all of the details shown on the sketches have been transferred to the field sheet. The field sheet should then be taken out in the field and compared with the territory it represents, and any errors noted corrected, or any important details omitted, placed on it. This sheet, together with the field sketches and note books pertaining to same, is then turned in to the general office.

TRANSFER OF FIELD SHEETS TO THE GENERAL MAP.

When the field sheet is completed it is transferred to the general map. One draftsman should be able to do this work for three field detachments. He should have the office equipped as follows:

1 drafting table (size suited to size of sheets of general map).
White paper as cover for same.
1 set drawing instruments (complete).
1 steel straight-edge, 36-inch, graduated to 1-100 inch.
1 full circle steel protractor, arm 8 inches.
Assortment of drawing ink.
Tracing linen.
A reserve supply of paper, ink, etc., for the field detachments.
A systematic file for filing all field work turned in, and all office work.
The necessary tin tubes, safe, or other means of protecting all maps from the weather.

The room in which the work is done should be so constructed as to be little affected by weather conditions.

Tracing linen is used for the sheets of the general map. These sheets may be made any convenient size; they may be much larger than the field sheets. The edges of these sheets represent coordinates of the general triangulation system. The coordinate lines of the edges of the field sheets are located on these sheets, and the field sheet transferred to the general map by tracing.

CONSTRUCTION OF MAPS OF CLASS II AND CLASS III.

The method of constructing these maps is very similar to that explained in Class I. In this case, however, a great part of the work is done by reconnaissance, so the organization of the party is different. For maps of Class II, there should be one transit party to two reconnaissance parties; for Class III, one transit party to four reconnaissance parties. The transit parties are the same as the field parties mentioned in Class I. The reconnaissance parties should have two men each, one sketcher and one assistant.

The control for these maps is obtained almost entirely by traverses run by the traverse parties. The general control, where possible, is obtained from such data as may be obtained from existing maps. If none can be obtained, that obtained by the transit traverse is accepted.

The work of the transit party is identical with that of field parties in Class I. The method of constructing the field sheets and general map is also the same as for Class I.

The best method for constructing the reconnaissance sketch is the method explained by Captain Sherrill, Corps of Engineers, in his book on that subject.

RECORDS OF CONSTRUCTION OF THE MAP.

The importance of keeping a complete record of all data and information used in the construction of maps has been mentioned above. If these maps be used for the land defense for which they are constructed it will be an indefinite time after their construction. The maps should be revised every ten years or less if necessary, and the plans modified accordingly. A complete record of construction will greatly facilitate this work. The complete records should contain the following:

File of triangulation books.
File of traverse books.
File of field sketches.
File of field sheets.
File of original sheets of the general map.

PLANS.

Upon the maps constructed above will be drawn the plans for all the field fortifications, camp sites, pipe-lines, wharves, etc. These will be of the proper scale and accompanied by a sufficient number of cross sections to fully explain the details of all of these works. These plans will be accompanied by suitable specifications for their construction. An estimate of the number of men required to construct each part within the prescribed time, and a suitable organization for each working party should be given.

For all this work the Board will give the general outline, and the

Engineer officer, detailed as mentioned above, must work out the details, subject, of course, to the approval of the Board. For the field fortifications, the most recent development in same should be carefully studied. Type forms of redoubts and trenches can be obtained from the Chief of Engineers. These, however, will be of assistance only in a general way. The actual form, size, shape, etc., must be designed to suit the terrain. Information for plans for camp sites, lines of communication, etc., can be obtained from the Field Service Regulations. For the pipe-lines, wharves, storehouses, etc., suitable authorities on civil engineering should be consulted.

The methods, organization, and equipment explained above were those adopted after about two years' experience in this work. At first, various methods, etc., were tried, but none seemed to be as satisfactory as the above. It has been found that difference in the terrain requires modifications in the minor details of constructing the field sketch. The variety of terrain is too numerous to make it practicable to give these minor details. If the general methods of construction, organization and equipment explained above are used, an officer, although he has had no previous experience, should have no difficulty in adapting them to the work at hand.

Reversed Parker Bear-Traps, Dam No. 13, Ohio River

BY

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In the slackwater improvement of the Ohio River, bear-trap weirs have been built, or are contemplated, in connection with all the dams above Louisville. They are of the two-leaf type except at Dam No. 13, where two gates of the Reversed Parker three-leaf type with Idler have been built. It is proposed to give a short account of these Parker gates.

The concrete foundations for the bear-traps at No. 13 were designed with a view to using the two-leaf type, but before the leaves themselves were built the Reversed Parker trap was decided on. A discussion of the Parker trap naturally leads to comparison with the two-leaf type, not only because such were originally intended for No. 13, but because they had been built at other points on the Ohio River before and after these were.

Plates and illustrations herewith show construction and positions of one of the Parker gates at No. 13 and a two-leaf gate such as is used elsewhere. The depth of foundation rock at No. 13 is used in the drawings for both types. Both are raised by the pressure of upper pool acting under the leaves, occasionally assisted by the buoyant effort obtained by replacing water by air in a chamber under one of the leaves.

The standard two-leaf type (Figs. 1-8) consists of an upper leaf having a fixed horizontal line of hinges at its upstream end and a lower leaf having a fixed horizontal line of hinges at its downstream end. The upper leaf overlaps the lower leaf, and as the leaves rise and fall they inclose a varying volume between themselves and the foundations under them. This volume is bounded on each side by two piers, each leaf extending from pier to pier. The lower leaf is steel throughout, which consists of a

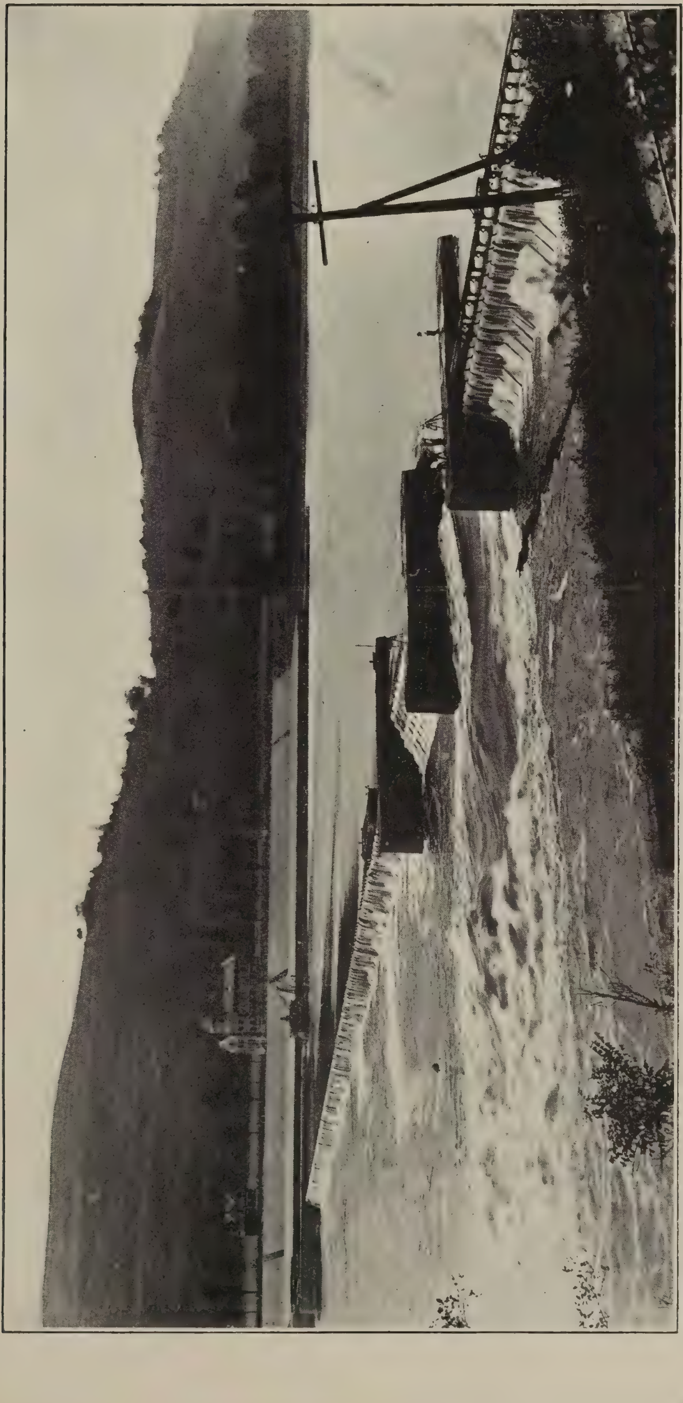


Fig. 1. General view of Lock and Dam No. 11, Ohio River. Chanoine Weir with service bridge in immediate foreground, then two standard bear-traps with piers, navigable pass and lock. Power-house and two lock-keeper's houses on far shore. Later dams will have in addition a power-house in the river wall to use water power,

series of girders about 35 feet long, each girder varying in depth up to a maximum of 5 feet. The girders are placed 5½ feet apart side by side, each one extending in an up and downstream direction and hinged at its downstream end to a hinge pedestal firmly embedded in the concrete foundation. They are connected with several lines of horizontal cross plates running normal to them, as deep as the girders and strongly connected to them. There are cover plates on top and over part of the bottom which are reinforced just over and under the horizontal cross plates referred to above, so that with them they make practically a second line of built-up girders at right angles to the first set and are normal to the current. The plates act as the webs and reinforced cover plates as flanges. All connections are strong, so that when completed the leaf forms a very strong cellular construction, practically air-tight throughout, except for part of the bottom where the cover plates are omitted. Where not objectionable otherwise, buckle plates are used as cover plates so as to get the greatest possible strength against warping. Two of the regular up and downstream girders in addition to the end ones are made air-tight, so that the leaf is divided into three compartments, each one fed compressed air by a 3-inch air-line. The lower leaf is the one depended upon to raise the trap, and should the head of water be insufficient air is forced into the leaf, the water escaping at the bottom. The upper leaf is much simpler and lighter in construction. There is an 18-inch I-beam opposite each one of the 5-foot girders in the lower leaf. These I-beams are connected with each other by plates and angles, making a skeleton steel leaf which is filled with timber. It is quite flexible, and depends for its stiffness upon the lower leaf on which it rests on one end and the line of hinges to which it is attached at the other end. This leaf is not entirely water-tight, but must be at least tight enough to allow operation by water pressures, which requires the water to flow away from the chamber under the bear-trap when the water valves in the piers are open to the lower pool, and closed to the upper pool. The horizontal section through the piers and bear-trap foundations in Fig. 5 shows the standard water conduits for operating the gates, although they differ somewhat from those actually built at No. 13. There is a 5-foot circular conduit extending all the way across the head or upstream end of the bear-trap foundations and piers and open at each end into the river on the side of a pier away from the bear-trap leaf. At these two points the surface of the water is not lowered when the bear traps are open as it is in the space between the piers and at their head. Full head of upper pool may thus be obtained in the conduits.

From this head or cross conduit four 5-foot conduits run through the piers into lower pool, one extending along each side of each bear-trap. This puts two conduits in the middle pier. From these conduits openings without valves extend into the space under the bear-trap leaves and there are valves in each conduit above and below these openings. Then by closing the valve below these openings and opening one above the space under the bear-trap leaves fills from upper pool, and by reversing these valves the space drains to lower pool. In this way the leaves are ordinarily raised or lowered.

A 4-inch air line brings compressed air from the power-house and is connected to three 3-inch lines.

Each 3-inch line is controlled from the top of an adjacent pier, and may be used for forcing air into, or allowing it to escape from, any one of the three compartments of the lower leaf. By having the three compartments and also by providing for the escape of air, as well as forcing air into the trap, the operator has better control over the trap should one end rise ahead of the other, or in many other contingencies. When there is no head of water whatever, say, in an open-river stage of 8 or 9 feet, the bear-trap can be raised with its upper portions 6 to 8 feet above the water by merely filling the lower leaf with air. Some of the two-leaf traps in the Pittsburgh District have been operated as often as forty-eight times in a single month with the use of water alone. About the only time air is ordinarily used is at the beginning of the operating season, for after they have been lowered all winter they are covered with mud, sand, gravel, etc., and the hinge joints are stiff. In such cases it may be necessary to apply air until they become loosened up. With normal upper and lower pools, the leaves can be either raised or lowered in two or three minutes without the use of air.

The up and down range of movement of the normal trap is 15 feet, while the length between piers is 91 feet; that is, it can open and close a cross section of the river 91 by 15 feet. If built at No. 13, the 91-foot dimension would presumably have been 83 feet, corresponding to those installed.

The Reversed Parker, as built at No. 13 (Figs. 4, 9, 11) consists of the upper leaf, the lower leaf, and the intermediate or Z-leaf.

In addition, there is an idler which consists of a number of parts, each one looking about like an ordinary wooden Chanoine wicket, about 4 feet wide, 16 feet long and 1 foot thick. The parts are placed side by side, and hinged at the upper end to the crest of the bear-trap and intended to keep drift from lodging. The lower leaf is made entirely of timber, except near its upper end are bolted four 12-inch 40-pound steel channels parallel to the line of hinges. This was to give strength in the longitudinal direction of the leaf or perpendicular to the current. The hinges, of course, are of metal, that is, cast steel. The upper leaf is also built of timber. Throughout its length, on the bottom of the leaf, runs a box having the leaf for its top and having no bottom. This was intended to give longitudinal strength and to provide an air chamber which could be filled to assist in raising the gate when necessary. The air issues from the pipes underneath the chamber, as shown on the cross section and, escaping through the water, is caught in the box. There is no provision for getting the air out of the chamber, leakage being depended on. The reader will observe that as the bottom of the air chamber is open, it is not possible to have much air in it, except when the bear-trap is down. However, it is just at this time that the air is most needed. After the bear-trap is once started, it shuts off part of the spillway and assists in collecting a head of water in the upper pool. The air chamber is divided into three parts by two air-tight bulkheads. The intermediate or Z-leaf is of all steel construction, having 52½ by ½ inch web plates and 7 by 3½ by ½ inch single-flange angles forming a Z-shape girder 53 7-16 inches deep by 82 feet 9 inches long, which is joined to the upper and lower leaves of the trap by cast-steel hinges with pin connections.

There are two bear-traps at No. 13; one as shown on Fig. 10, with a vertical movement of 15 feet, and the other one with a 12-foot movement. They are each 83 feet long from pier to pier. The district officer early in 1906 requested that the Parker gates be used at Dam 13 instead of the two-leaf type. At that time a form of two-leaf type had been used in the Pittsburgh District with a lower leaf of more flexible construction than the present two-leaf standard type outlined above and with a length between piers of 120 feet. These bear-traps had proven too flexible and have since been strengthened. In the meantime, additional bear-traps were being built in the Pittsburgh District much like the present standard. The district officer, in requesting authority to

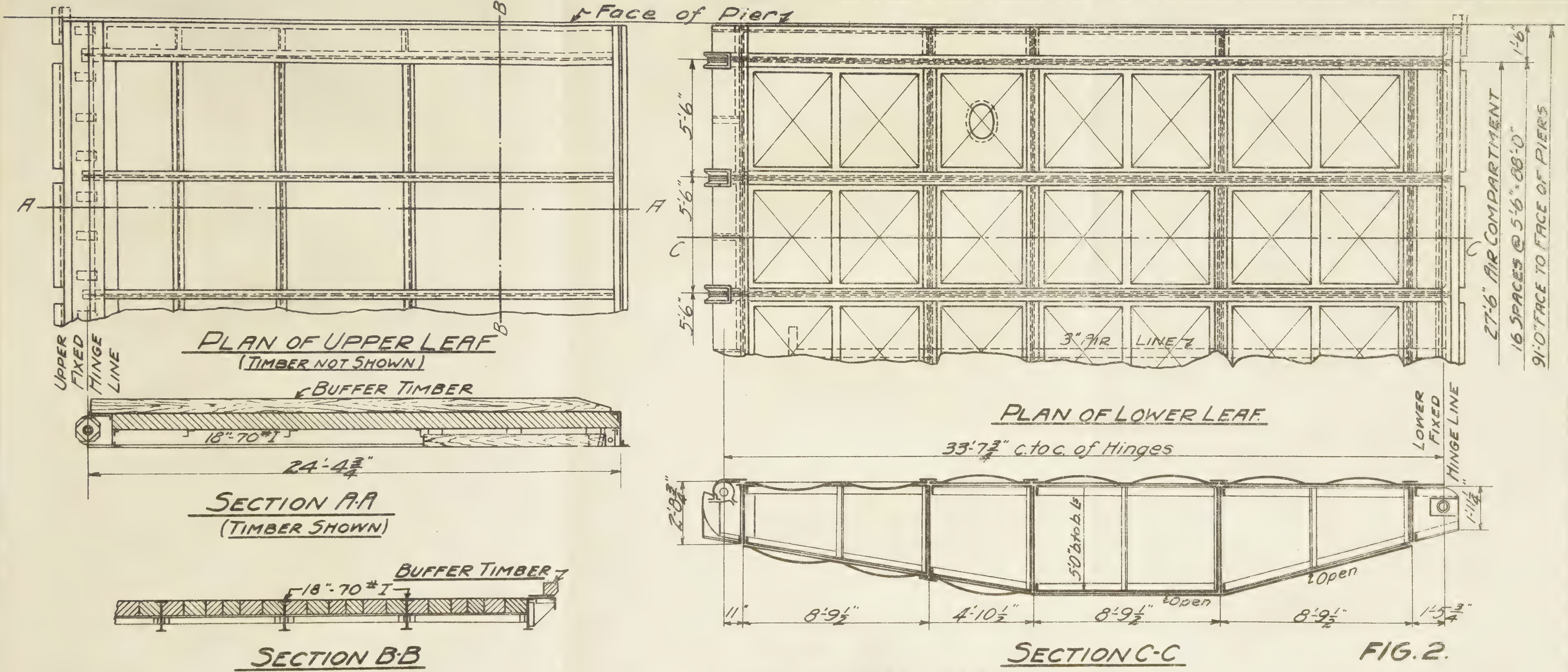

Face of Pier
B
B
A
A
PLAN OF UPPER LEAF
(TIMBER NOT SHOWN)
UPPER FIXED HINGE LINE
BUFFER TIMBER
18"-70# I
24'-4¾"
SECTION A-A
(TIMBER SHOWN)
BUFFER TIMBER
18"-70# I
SECTION B-B
5'-6"
5'-6"
5'-6"
C
C
3" AIR LINE
1'-6"
27'-6" AIR COMPARTMENT
16 SPACES @ 5'-6" = 88'-0"
91'-0" FACE TO FACE OF PIERS
PLAN OF LOWER LEAF
LOWER FIXED HINGE LINE
33'-7¾" c. to c. of Hinges
2'-8¾"
1'-11¼"
5'-0" b. to b. L's
℄ Open
℄ Open
11"
8'-9½"
4'-10½"
8'-9½"
8'-9½"
1'-5¾"
SECTION C-C

FIG. 2.

LEAVES OF STANDARD BEAR TRAP

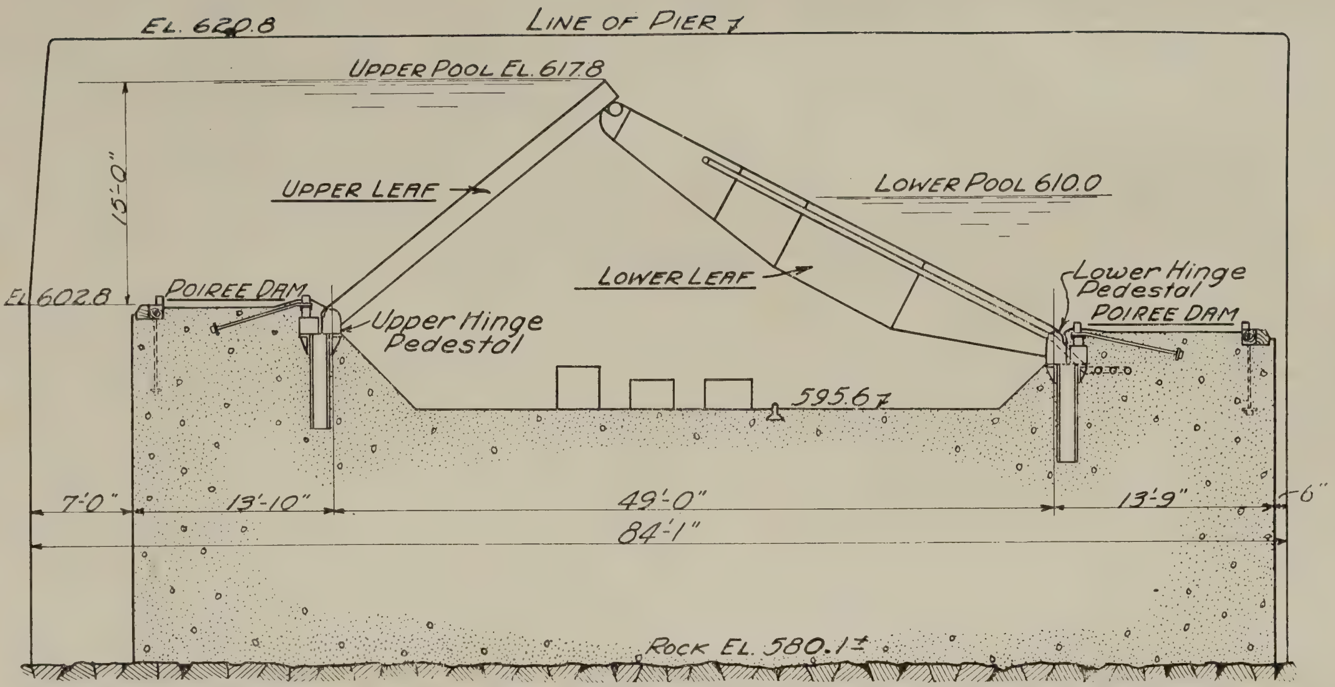

EL. 620.8
LINE OF PIER
UPPER POOL EL. 617.8
15'-0"
UPPER LEAF
LOWER POOL 610.0
LOWER LEAF
EL 602.8
POIREE DAM
Upper Hinge Pedestal
Lower Hinge Pedestal
POIREE DAM
595.6
7'-0"
13'-10"
49'-0"
13'-9"
6"
84'-1"
ROCK EL. 580.1±

Fig. 3. Cross section showing a design for the standard two-leaf bear-trap, to take the place of the large Reversed Parker actually built at No. 13, Ohio River. The air lines are shown in the concrete and one line shown running into the lower.

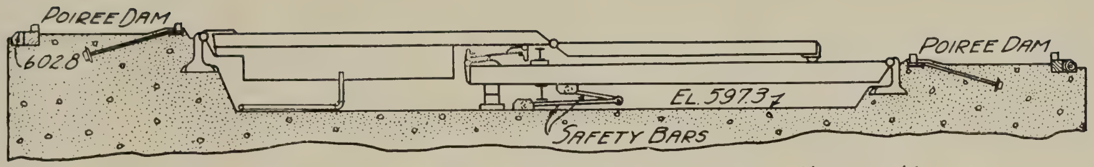
build the Parker gates, wrote as follows to the Chief of Engineers:

> The main advantages of this form over the two-leaf type are: (1) it will be cheaper to construct because wood is used to a greater extent; (2) it will be cheaper and more convenient to operate because compressed air will not ordinarily be required and the consequent trouble and expense of running the engine will be avoided; (3) it will be cheaper and easier to maintain because the frequent painting to prevent corrosion will be avoided, and spikes can be used in repair work; (4) it will be stiffer because of the intermediate leaf; (5) it will be safer and more reliable because the leaves can not separate so as to interfere with its operation or cause destruction; (6) its operation can be controlled by adjusting the counterweights on the lower leaf so that it will rise from the bottom with as small a head of water as may be desired; and (7) it can be raised either by air alone or by water pressure alone.
>
> It differs from the two-leaf type now building at many of the Ohio River dams in that (1) it is constructed mainly of timber, (2) it can be operated by two independent methods, (3) it has its upper and lower leaves connected by a third leaf, (4) it has an idler attached to the end of the upper leaf which rests on the lower leaf.

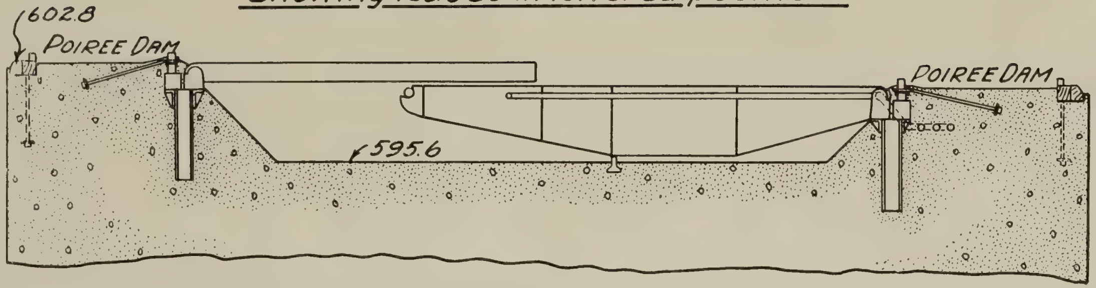
The cost of the large bear-trap at Dam No. 13 was approximately $20,000.00. The cost of a standard two-leaf trap of the same size would have been about the same.

The bear-traps were completed in the fall of 1908. The large one was operated five or six times, after which (1909) it began to give trouble. It was impossible to bring it to a raised position, although it could it could be started from the bottom. It could not be brought up uniformly; that is, with the highest line of the leaves horizontal, although all available means were tried. It seemed to start properly, but before it emerged from the water one side or the other was in advance.

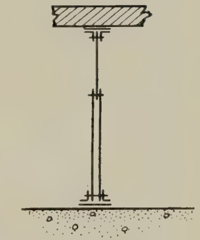
The upstream edge of the downstream or lower leaf would gouge into the concrete pier on the side of the leaf least advanced. At the other pier, the upstream edge of the leaf would move 6 or 8 inches away from the pier. As one side got higher the air in each compartment rushed to that end, pushing the high end still higher and also digging the metal edge of the leaf deeper into the pier at the other side. There was no way to allow the air to escape except to leak out with time. One side would advance 4 or 5 feet ahead of the other before the bear-trap stopped and until the movement upward began it was impossible to say which side would come first. It could always be dropped to its lowered position and another


POIREE DAM
602.8
POIREE DAM
EL. 597.3
SAFETY BARS

Cross-section of beartrap as actually built showing leaves in lowered position.


602.8
POIREE DAM
POIREE DAM
595.6

Cross-section of two leaf beartrap which would have been required in place of Parker gate, showing leaves in lowered position.



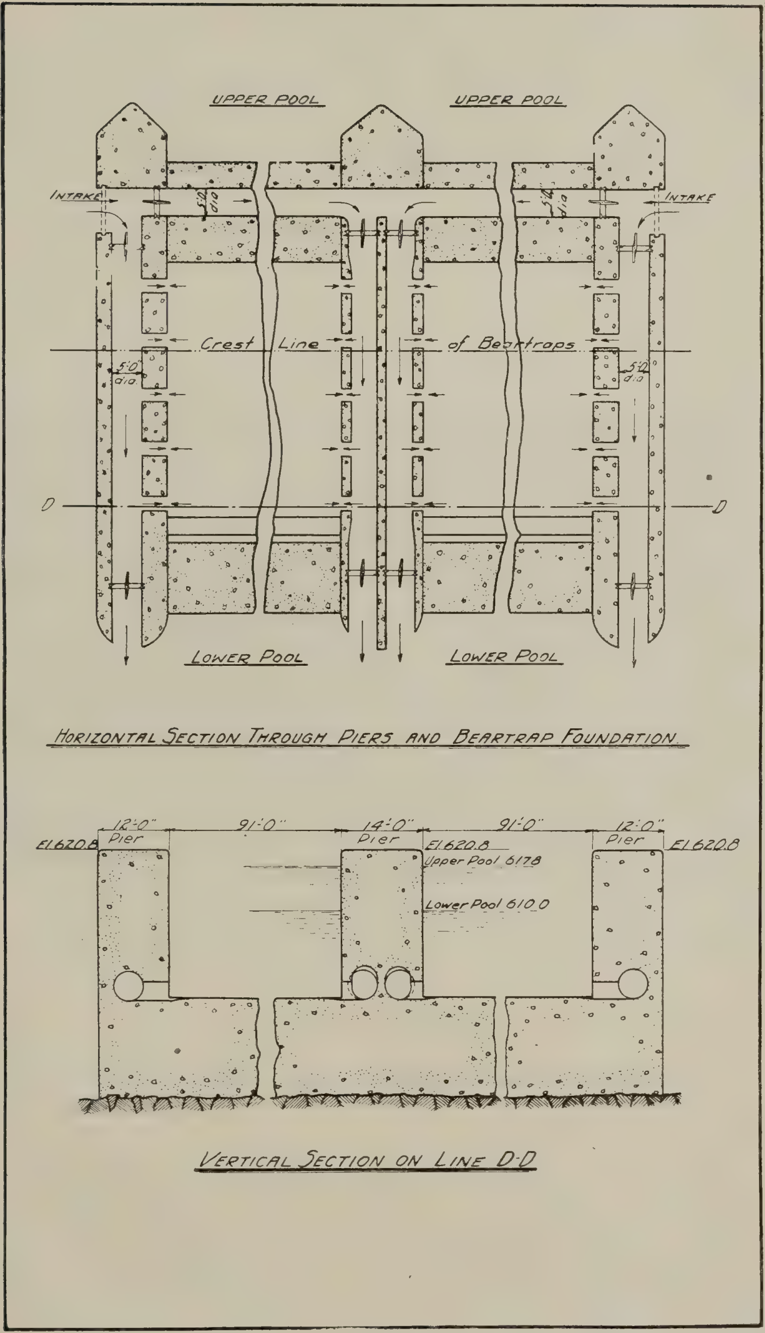
Safety Bars Spaced 4'0" C to C.

Fig. 4.

effort made to raise it. The water was allowed to come under the bear-trap (in an effort to raise the bear-trap properly), first from the right-hand and then from the left-hand pier; air was admitted in different amounts into the three air chambers. A hoisting engine was also attached by means of block-and-fall to bear-trap, first next to one pier and then next to the other, and was used to help raise the lagging end. By such means, after much effort the bear-trap was raised. At last the large bear-trap not only absolutely refused to come up, but also refused to be lowered fully, sticking in an intermediate position. The small bear-trap operated somewhat better, but not satisfactorily.

There are safety bars attached to the bottom of the lower leaf for holding it to the concrete, thereby limiting its range of motion. They are shown in the raised and lowered sections of the bear-trap, in Figs. 4 and 10, and also shown in a small sketch on one side of Fig. 4. They consist of three eye-bars, arranged as shown, and which close up like a jack-knife when the dam is lowered. It was thought that the arrangement (not shown) for keeping these bars off dead center might have been inadequate and that some of them had probably gotten in such position when the bear-trap was raised, and when it was later lowered they had refused to close up, instead bending sideways towards one pier or the other. The water seals (not shown) between the lower leaves and the piers were known to be in bad condition. It was accordingly decided to unwater the traps. A contract was let for extending the foundations up and down stream to provide foundations for Poiree dams, which was the approved construction at other points on the river. In the drawings the foundations are shown with these additions; Poiree Dam is also shown in one drawing. A cofferdam had to be built around the entire bear-traps and piers to do this work, and while it was unwatered, the bear-trap leaves were to be repaired. All arrangements were made for repairing the gates preparatory to unwatering the cofferdam.

On examination, after unwatering, the safety bars were discovered in good condition in both bear-traps. The water seals in both bear-traps were badly damaged. The intermediate leaf of the big bear-trap was entirely broken in two, the tear running the full 83 feet of its length, from one pier to the other. It doubled back on itself like a jack-knife (Figs. 12 and 13). Part of the hinges connecting the intermediate leaf to the other leaves were also broken. The water seals in both traps were replaced by what was con-



UPPER POOL
UPPER POOL
INTAKE
5'0" dia
5'4" dia
INTAKE
Crest Line of Beartraps
5'0" dia.
5'0" dia.
D
D
LOWER POOL
LOWER POOL
12'-0"
91'-0"
14'-0"
91'-0"
12'-0"
El.620.8
Pier
Pier
El.620.8
Upper Pool 617.8
Lower Pool 610.0
Pier
El.620.8

HORIZONTAL SECTION THROUGH PIERS AND BEARTRAP FOUNDATION.

VERTICAL SECTION ON LINE D-D

Fig. 5. Showing arrangement of water conduits and valves for raising and lowering leaves of the standard type. Air lines, which may be used to assist, are not shown.

sidered a better form, and the leaves were chipped off to give more clearance between themselves and the piers. A new intermediate leaf was put in the big trap and the broken hinges replaced by others with as much increased thickness of parts as clearances would allow. The original intermediate leaf had no stiffener angles and a large number of these were added. A form of built-up girder was added for reinforcing the upper leaf. It is marked on Fig. 10 as a ''reinforcing girder.'' It is in the form of a large Z-bar 29 inches deep, and the full length of the bear-trap, added along the side of the air chamber and firmly bolted to it and to the leaf above. It was felt at that time that this was a very inadequate provision, as the leaf was still very weak longitudinally as compared to the standard traps, but it was impossible to add an appreciably deeper girder because it would have projected too far below the leaf, and it would also have been a very troublesome matter to connect it firmly to the rest of the bear-trap. In the small trap, stiffener angles were also added on its intermediate leaf, but no reinforcing girder was put on.

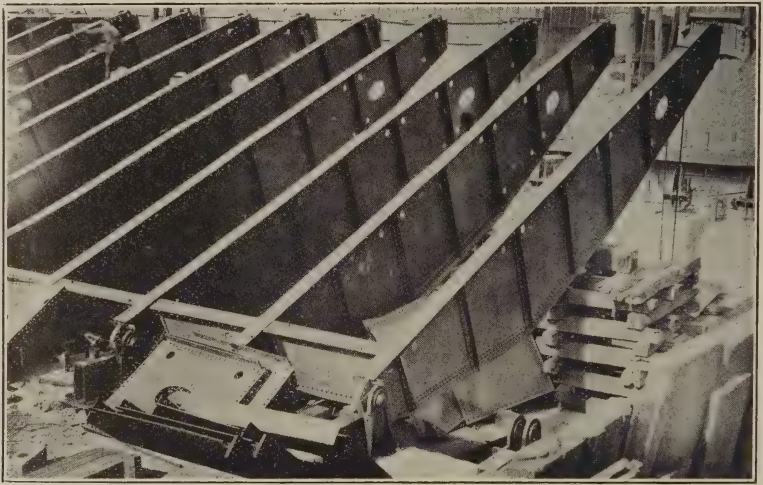


Fig. 6. Standard lower leaf under construction, showing main girders in place.

After the cofferdam was flooded, the small bear-trap operated fairly well but the large one seemed to be more limber than ever. When an effort was made to raise it, it came up more unevenly than before; one edge of the trap advancing about 8 feet higher than the other; the rear portion, as usual, digging into the concrete, while at the other pier the high end was 6 or 8 inches away from the pier. Figures 14 and 15 show the large bear-trap when, in the summer of 1911, these efforts were made to raise it. To the observer on the spot it looked even more twisted than it does from the photographs, and one naturally expected it to snap asunder at any time. When the bear-trap is raised further at one end than at the other, the topmost edge assumes a compound curve and the leaves are warped, which must introduce very heavy stresses. The bear-trap was lowered from the position shown apparently unhurt. Afterwards, by working the water valves, by the use of air and with the assistance of a hoisting engine, it was raised several times. The intermediate leaf was on examination found to be intact

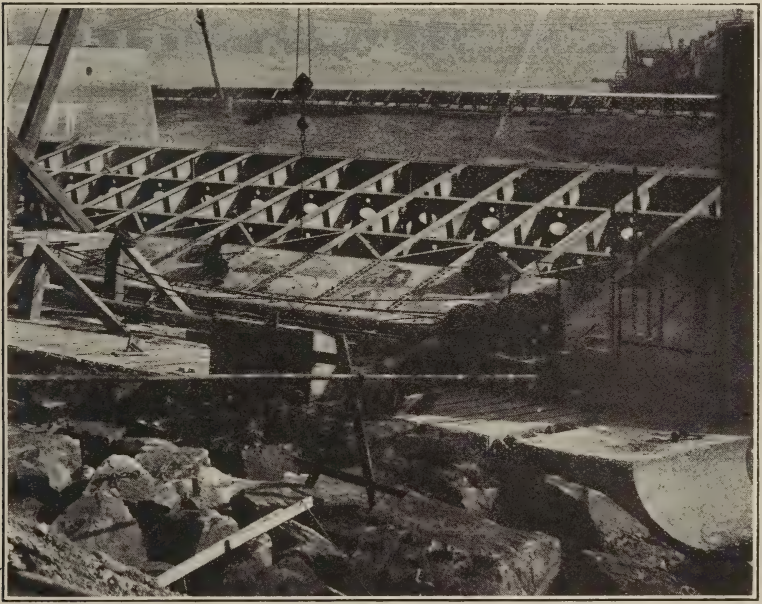


Fig. 7. Standard lower leaf under construction after cross girts and some cover plates have been put on.

It was felt that very little progress had been made in making these bear-traps satisfactory and during the 1912 season another effort was made to repair them. Two pier rollers were added to the upper leaf of the bear-trap and are shown in the plan and in the section of the upper leaf on Figs. 9 and 16. These rollers were placed so that they would be the only points where the bear-trap leaf could bear against the pier and it was thought that if the leaf could be kept from digging into the concrete the advanced portion of the bear-trap would drag the other portion with it until the entire trap was raised. To insure a good bearing for the rollers on the face of the pier, metal plates were placed in the pier to form a run-way. The rollers are 8 inches in diameter and 1 foot long. The castings which hold the housings for the pin are turned downward at right angles at the end next to the pin, so that a force pushing the roller away from the pin would tend to make this end or arm crush into the wood of the leaf. The casting was fastened to the leaf by bolts. At the time these pin rollers were placed it was remarked that they looked weak and later experience showed this to be true. It developed that a large force is exerted pushing the leaf against the pin and this overcame the hold-down bolts and bent the vertical arm of the casting. This point was strengthened. The roller pin, which was 1¾-inch tobin bronze, sheared and bent, due to the same force and was replaced by a 2¼-inch tool-steel pin, which so far has been satisfactory. Due to an unfavorable season, rollers were installed in the small trap only before the season of high water arrived.

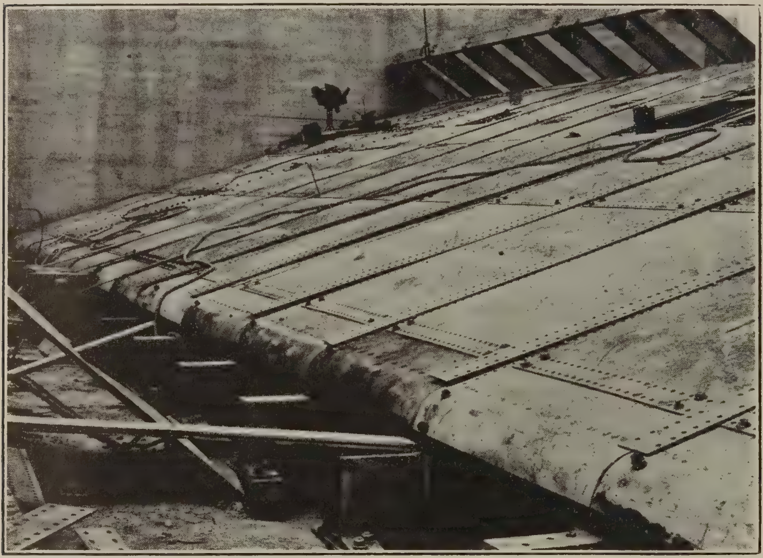


Fig. 8. Standard trap under construction. Steel leaves nearly completed. Steel frame of upper leaf shown projecting above lower leaf. Leaves, as shown, are intermediate between raised and lowered positions.

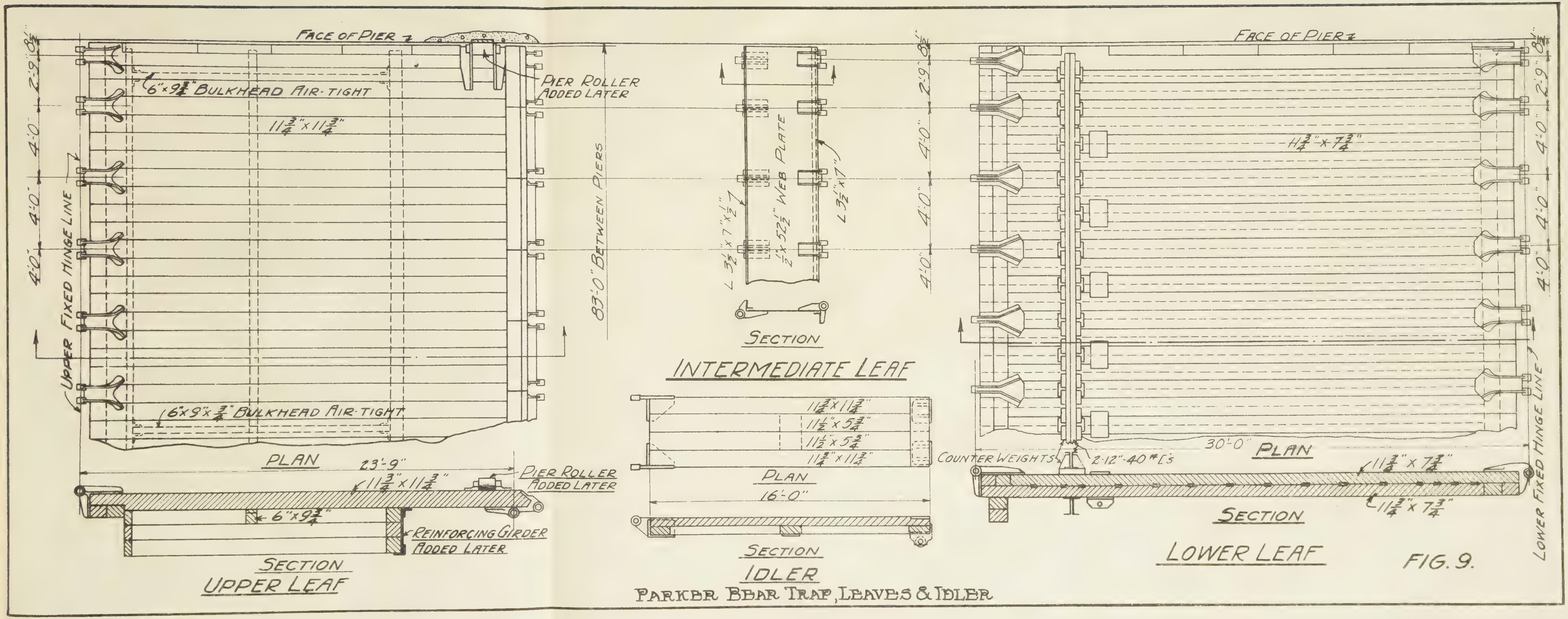

FACE OF PIER
PIER ROLLER ADDED LATER
6"×9¾" BULKHEAD AIR-TIGHT
11¾"×11¾"
83'0" BETWEEN PIERS
UPPER FIXED HINGE LINE
6"×9"×¾" BULKHEAD AIR-TIGHT
2'9" 8½"
4'0"
4'0"
4'0"
PLAN
23'-9"
11¾"×11¾"
PIER ROLLER ADDED LATER
6"×9¾"
REINFORCING GIRDER ADDED LATER
SECTION
UPPER LEAF
L 3½"×7"×½"
½"×52½" WEB PLATE
L 3½"×7"
SECTION
INTERMEDIATE LEAF
11¾"×11¾"
11½"×5¾"
11½"×5¾"
11¾"×11¾"
PLAN
16'-0"
SECTION
IDLER
2'9" 8½"
4'0"
4'0"
4'0"
FACE OF PIER
11¾"×7¾"
30'-0"
PLAN
COUNTER WEIGHTS
2-12"-40# ['s
11¾"×7¾"
11¾"×7¾"
SECTION
LOWER LEAF
LOWER FIXED HINGE LINE
2'9" 8½"
4'0"
4'0"
4'0"

FIG. 9.

PARKER BEAR TRAP, LEAVES & IDLER

During the season of 1913, while preparations were in progress to put the pier rollers on the large bear-trap, the small bear-trap gave way in a new point. This was reported by Mr. Duis as follows:

> 14. On the evening of July 28th, a very hard, local rain storm occurred between Wheeling and Dam No. 13, causing the pool to rise very quickly, and as it seemed likely to go over the top of the lock gates, the lockmaster decided to lower the small bear-trap. The upper valves were closed but the instant the lower valves were opened, instead of trap going down as usual, the crest of the top moved downstream several feet and upward several inches from normal, and remained in that position. Owing to the darkness, nothing further was attempted that night. A closer examination the next morning showed also that the upstream side of upper leaf had separated from its anchorages and was resting on the chamber floor about 4 feet downstream from its normal position. The lower leaf still acted as a dam and held the pool, due to the pressure of this leaf being taken by anchors to the floor instead of by the upper leaf as in the two-leaf type. The lower valves had been left open since the evening before and when they were closed the upper leaf came up, its downstream side resting over the lower leaf and the upstream side protruding from the surface of water in the upper pool. (Fig. 17.)

If the leaves and idler when the dam was down had been torn loose from the upstream hinge pedestals and the trap rotated as a whole about the downstream fastenings through an angle of 30 degrees, more or less, the result would have been approximately the position which the bear-trap now assumed, the leaves and idler being in about the same relative positions that they have when the dam is down. The safety bars under the lower leaf prevented it from moving farther, while the general equilibrium of the forces held the rest of the trap in its position, the trap still acting as a portion of the dam. Examination showed that the large bear-trap had ripped loose from a few of its upper hinges and could no longer be relied on. As Dam No. 13 is peculiar in having no weir except these two bear-traps, the situation became dangerous. It is unnecessary to explain the details of the situation; it will suffice to say that the river was low and remained so until the large bear trap was repaired which improved conditions somewhat, but the District Office was in a constant state of anxiety lest it be found necessary to drain the pool suddenly and deprive Wheeling and vicinity of its harbor during the low water season, or else that a sudden rise in the river would result in serious injury to the dam. Before the season closed both traps were repaired and strengthened along their upstream line of hinges.

COMMENTS.

These bear-traps, finished in 1908, have never, to include the season of 1913, worked satisfactorily. The cost of repairs was very high and they were a constant source of anxiety. The natural inference is that these bear-traps were a very poor substitute for the two-leaf type which worked so satisfactorily; but it may be well to examine why this is true. Referring first to the seven main advantages given by the District Office in requesting authority to build these gates, they will be taken in order:

1. "It will be cheaper to construct because wood is used to a greater extent." The two types, as shown from the cost of the Parker traps and standard bear-traps actually built, would have cost about the same.
2. "It will be cheaper and more convenient to operate because compressed air will not ordinarily be required and the consequent trouble and expense of running the engine will be avoided." Later experience has shown that air is ordinarily not used for the two-leaf type either, hence this advantage reduces to nothing.
3. "It will be cheaper and easier to maintain because the frequent painting to prevent corrosion will be avoided, and spikes can be used in repair work." While this has not been borne out by the first five years, the high cost of operation was due to the many breakdowns. With a trap designed in the light of present experience it may be cheaper to maintain, although it will probably be built of steel. Moreover, the relative cost of operation can not be determined until a longer period has elapsed, possibly until after it has been necessary to replace each type.
4. "It will be stiffer because of the intermediate leaf." The intermediate leaf does not seem to act as a stiffener in the way that it might have been expected, as evidenced by the photographs and the behavior generally of the traps. The Z-leaf, considered as a strengthener to the lower leaf, evidently acts to best advantage if at right angles to it. But it is less than 4½ feet wide while the main girders and some of the cross girts in the standard type lower leaf are 5 feet deep, so that it could hardly be expected to be as stiff.
5. "It will be safer and more reliable because the leaves can not separate so as to interfere with its operation or cause destruction." No trouble has been experienced with the two-leaf type nor any anxiety felt in this matter, and they are considered as safe as the three-leaf type.
6. "Its operation can be controlled by adjusting the counterweights on the lower leaf so that it will rise from the bottom with as small a head of water as may be desired." This is true and might possibly be useful in experimenting with a new design, as this was. The two-leaf type was designed with a view to operating under all the heads which actually exist in practice and which

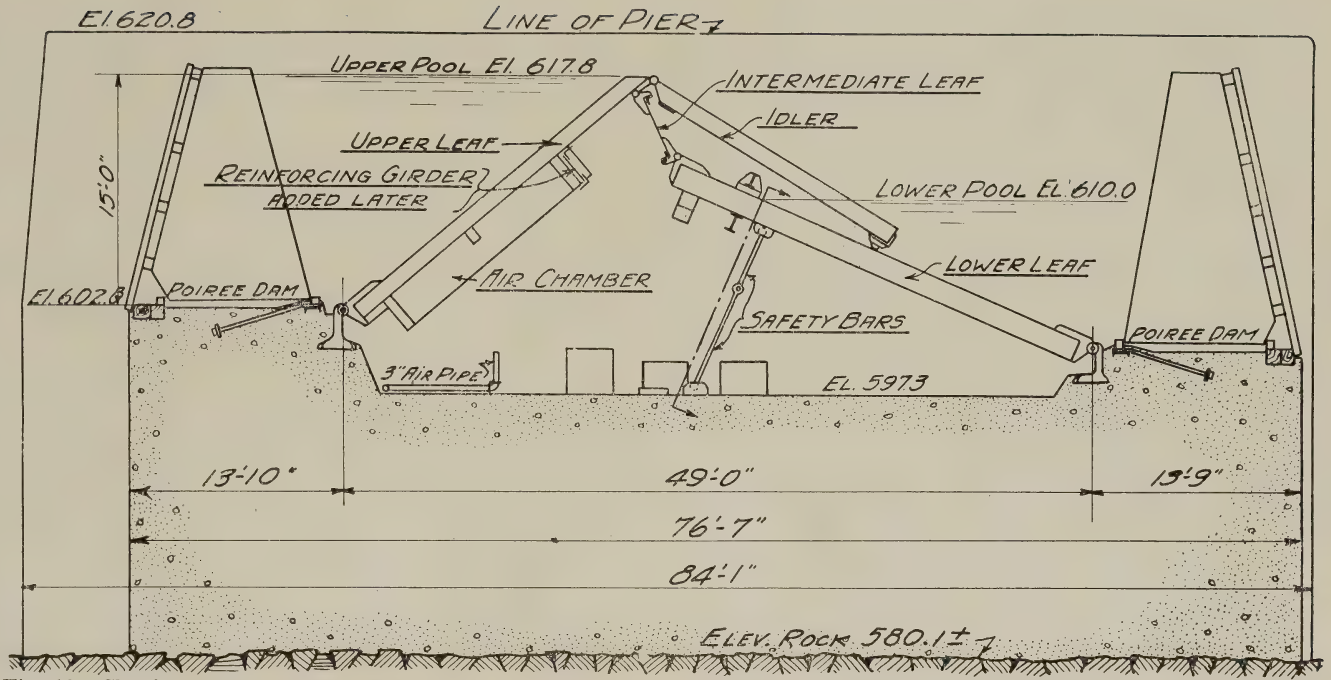

El. 620.8
LINE OF PIER
UPPER POOL El. 617.8
INTERMEDIATE LEAF
IDLER
UPPER LEAF
REINFORCING GIRDER ADDED LATER
LOWER POOL El. 610.0
15'-0"
LOWER LEAF
AIR CHAMBER
El. 602.8
POIREE DAM
SAFETY BARS
POIREE DAM
3" AIR PIPE
EL. 597.3
13'-10"
49'-0"
19'-9"
76'-7"
84'-1"
ELEV. ROCK 580.1±

Fig. 10. Showing cross section of large Reversed Parker Bear-Trap No. 13, Ohio River. The Poiree Dams with foundations and pier extensions and reinforcing girder were not constructed originally.

are quite large, and its operation has been successful. A good bit of latitude must be allowed for varying heads, for mud, etc., and these change so much that the traps can not be too delicately balanced.

7. "It can be raised either by air alone or by water pressure alone." The same is true of the two-leaf type.

In these comparisons the district officer may have had in mind the 120-foot two-leaf bear-traps at Dam No. 6, Ohio River, which were found to be too limber. They were, however, operating, and continued to do so for a number of years before they were strengthened; and, in the meantime, a number of the standard type, 93 feet long, were being built in the Pittsburg District.

Large structures capable of movement such as these and operating under water should necessarily be built simply. The two-leaf type has two lines of hinges which are firmly connected to the foundation. The hinge pedestals are constructed so that the centers of the shaft hole in them can be accurately lined up, which is done to within one sixty-fourth of an inch. If the lower leaf is made stiff in the two-leaf type, nothing can get out of line because one end of it is firmly held by hinges so the whole leaf is firmly held, while the upper leaf which may be limber is firmly held at one end by its line of hinges and at the other end rests on the stiff lower leaf. The Reversed Parker gate with its four lines of hinges, two of them movable, can be seen at once to give more chance for warping and twisting with their consequent stresses.

In considering the stresses on the intermediate leaf, let us assume upper pool pressure in the chamber under the bear-trap and the trap nearly down and remember also that the Z-leaf as built had no stiffener angles. The pressure on the two sides of the upper leaf are then equalized; the pressure on the two sides of the intermediate leaf tends to push the trap down, while the pressure on the two sides of the lower leaf overcomes this and raises the trap. If in this position the upper leaf digs into the concrete pier and is so brought to rest, as frequently occurred at No. 13, a large force is transmitted through the intermediate leaf and as this force is nearly normal to the intermediate leaf its component along the leaf must be very large. Of course, you can make this force just as large as you want to by assuming the leaves more nearly parallel, but figures in the Wheeling Office indicate about 90,000 pounds per square inch fibre stress might easily have been caused if the metal could have stood it. Evidently a stress like this is what made

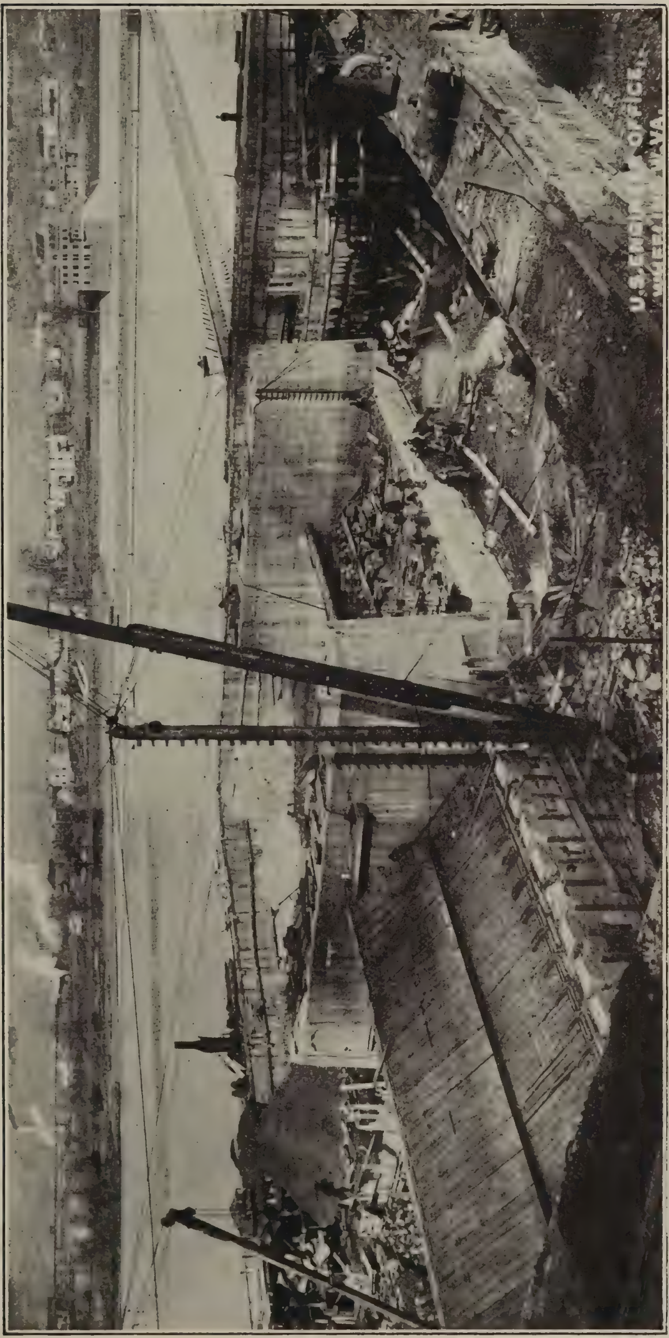


Fig. 11. General view of Lock and Dam No. 13, Ohio River, taken October 29, 1910. Preparations are in progress to extend the piers, and put in Poiree dam foundations. The large trap is being repaired by putting in a new Z-leaf and adding the reinforcing girder.

the leaf double up as the original leaf did in the large trap. A similar condition can arise if the lower leaf catches when the trap is being lowered.

When the small bear trap failed at its upper hinges, it will be remembered that that end of the leaf first moved downstream and dropped several feet to the concrete floor. Of this Mr. Duis in his report says:

> This showed that the failure of the bolts was in tension and not in shear as at first concluded, and as the bolts that failed were at the upstream end of the hinges and the hinges were fastened to top of leaf, the force to cause the failure must have been downward on the leaf. Such forces occur either during the lowering of the trap, or when it is hooked up during repair work and the water under it is at lower pool or entirely pumped out. In lowering the bear-traps, the pressure under it from upper pool is relieved the instant the lower valves are opened, but as it takes several minutes for the trap to go down, there is a varying pressure on the upper leaf during that time, beginning with nearly the total pressure due to head on dam and decreasing to nothing when the trap is somewhere near down. When the bear-trap is hooked up and water underneath at lower pool, the upper leaf takes full pressure from upper pool, and this condition has happened a number of times in both traps during repair work. A still greater pressure occurs when the chamber underneath is pumped out, and while this has never been done, it was intended to provide for stresses under this condition in the original designs. * * *
>
> Those leaves of the hinges which are fastened to the bear-trap leaves tend to rotate on their downstream ends, subjecting the five $\frac{3}{4}$-inch bolts not only to additional stresses, due to movements, but also allowing the full strength to be developed in only one bolt in each hinge, the one nearest the pins. For each 1,000-pound shearing stress on a hinge, the following tensile stresses occurred on the bolts, beginning with the one nearest the hinge pins: 912 pounds, 624 pounds, and 336 pounds, the remaining two bolts being so near to the fulcrum point of the hinges as to have no value in tension.

He also computed that the total unit tension on the big trap in these bolts was 65,000 pounds per square inch.

Attention is called to the pier rollers which, it is believed, are a good addition to the trap. If a new Parker trap were built for the Ohio River it would probably work satisfactorily without making the lower leaf as stiff as the one in the standard type, provided good pier rollers were added. Perhaps rollers could be used on the standard two-leaf type and thereby allow a somewhat less rigid but cheaper lower leaf, possibly one partly of wood which would not rust so much. It was, however, a combination wood and steel lower leaf at No. 6, Ohio, which was too limber and the standard type is so satisfactory that one is naturally much disinclined to change it and it probably will never be done until strong reasons therefor develop.

The great and, in the opinion of the writer, the only real superiority of the Reversed Parker type for use on the Ohio River consists in the fact that for the same height the bear-trap can have a narrower foundation, but as the foundation had already been built for the two-leaf type at No. 13 when the Parker Gate was decided on, that advantage was lost. If that advantage had been secured, the leaves also would have been shorter and that would have reduced their cost. Nevertheless, it is not apparent on the face of it that a satisfactory Parker Gate could be built for the Ohio River cheaper than the two-leaf type, because the leaves as built turned out to be very deficient in stiffness in all directions and a satisfactory trap would have to be a much more expensive type of construction than the one used. The more complicated construction and the idler naturally run up the cost.

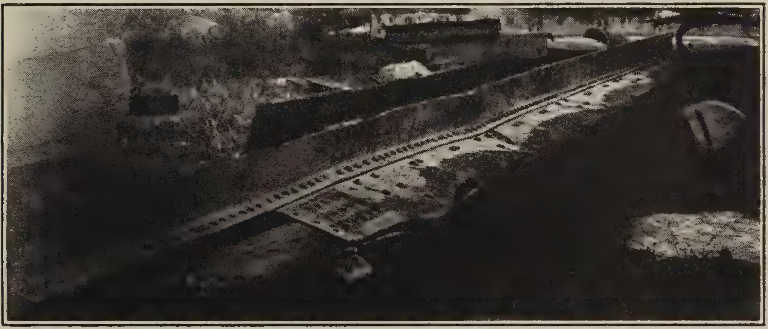


Fig. 12. Part of the Z-leaf, large Parker trap after it was removed and thrown on the river bank. Leaf is completely bent back on itself and ripped longitudinally.

With the knowledge at hand a good Reversed Parker Type of bear-trap could, it is believed, be designed for the Ohio River which would work, but no reason is known for doing so unless it could be shown that the final cost would be cheaper.

These traps have been a great disappointment to all concerned. So much was expected of them and so little was received. Almost every feature that might possibly have been questioned in the design turned out a complete failure. In addition, parts considered good failed. Perhaps the original designers were a little over sanguine.

The poor water seals were a detail. The weakness of the hinges and their fastenings and even the omission of web stiffeners from the Z-leaf were matters that could be overcome by repairs. The serious error and the one almost impossible of correction without entirely new leaves is the general lack of rigidity. As this was also the great weakness of the early two-leaf type on the same river, it would have been rather natural to strengthen the design here or in some way provide for this weakness.

Leaves which have suffered the stresses and strains of these can not have very much strength left in their original parts and some day before so many years it may be necessary to replace them entirely, and the cost of replacing them will add that much more to the expense account against them. But it is hoped that they will operate satisfactorily for a considerable period of time and that they will not trouble the District Officer and his assistants in the future as they have in the past.

Much of this article was written two or three years ago, while the writer was stationed at Wheeling, W. Va., in charge of these bear-traps, but the article has been changed and added to frequently since originally written—each new development in the operation of the traps required additions to the article. So many of the employees in the Wheeling District have given assistance in its preparation and have been engaged at various times in the repairs to these traps that it is impracticable to give all of them the credit due. Mr. J. A. McDonough and Mr. Charles Peterson are responsible for much of the design work in connection with the repairs; Mr. George Patrick as lock-master at No. 13 and as superintendent of construction carried on much of the work of the field; Mr. F. B. Duis, Assistant Engineer, was in local charge of the dams 11, 12, and 13, Ohio River, while most of the repairs were made; and Mr. H. B. Mish, Junior Engineer, was in charge of the earlier repair work and lent the writer much assistance in the preparation of this account. Mr. Fred Arthur made the drawings which have been reproduced and Mr. Wm. Kirchner the photographs.

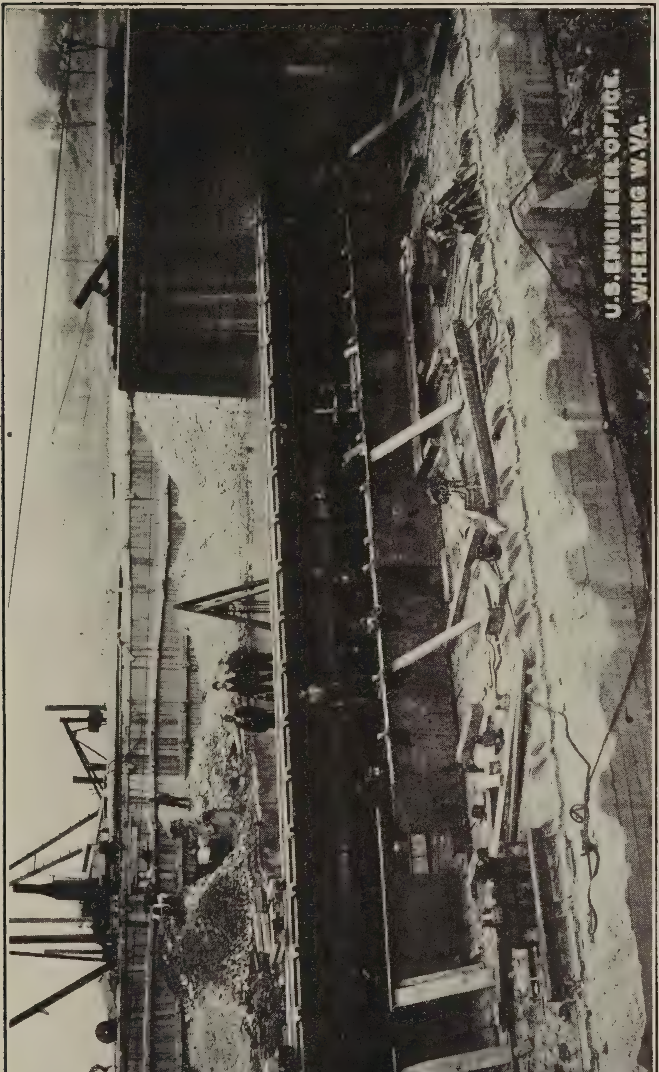

U.S. ENGINEER OFFICE
WHEELING W.VA.

Fig. 13. November 7, 1910, showing reinforcing girder attached to upper leaf, large Parker trap. The new Z-leaf is shown in several sections, standing on the lower leaf which is in its lowered position, making a floor on which to work.

Discussion

Maj. H. Burgess

Corps of Engineers; Member American Society of Civil Engineers

My experience with the three-leaf bear-traps has been with dams much shorter than those described by the author. In the Louisville District, of which I had charge for several years, there was a steel Parker gate closing the chute used for washing out the canal; and in the Chattanooga District there is a reversed Parker of steel and wood, in the drift chute of Colbert Shoals Canal; and there was destroyed about three years ago a wooden Parker gate in the drift chute of the Elk River Canal. These three gates were each 40 feet between abutments. The brief history of these bear-traps follows.

The L. & P. Canal Parker Gate.

The steel Parker at the Louisville and Portland Canal was constructed under contract in 1907. A drawing of this gate may be seen on page 263 of the 1903 edition of Thomas-Watt's ''The Improvement of Rivers,'' although the drawing is incorrectly marked as a reversed Parker and the X-leaf should be marked as the downstream leaf. Photographs of the operation of the gate are given in the Report of the Chief of Engineers for 1899, following page 2572. Height of crest above hinge of upstream leaf was about 15 feet and the base, measured between hinges, was about 21 feet, and the length 40 feet. The downstream leaf was of double-skin watertight construction; while the folding leaf was constructed of I-beams and with single skin. It was originally intended to install an idler, but this was omitted, and scrap iron was placed inside the downstream leaf in order to make up for this omission and to give the gate about equal weight to that of the displaced water. When first constructed, there was considerable leakage into the lower leaf, due to faulty workmanship; and the hinges in the fold of the upstream leaf were in faulty alignment. On first trial of the gate five of these hinges were broken, from which cause and from the leakage the gate could not be operated. Repairs were made by the United States at the expense of the contractor, the repairs consisting in the caulking and otherwise tightening up of the lower leaf, and in the substitution of one long hinge rod in the fold of the upstream leaf for the seventeen separate hinge-pins, thus insuring exact alignment.

Following these repairs the gate was successfully operated, except for one accident, until the changes now under way at the L. & P. Canal caused the closing of the flushing-channel and the abandonment of the gate. The accident referred to was in September, 1903, when upon trying to raise the gate following its being lowered for flushing, it was found that it would not move. Chains were attached to ring-bolts at the ends, and by the use of ratchets the gate

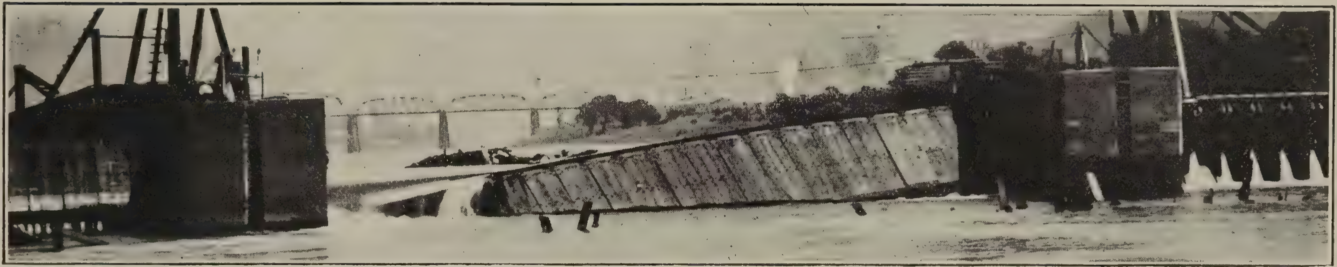


Fig. 14. July 6, 1911. Large Parker trap, No. 13, Ohio River, when effort was made to raise it after new Z-leaf and reinforcing girder were installed. View looking upstream.

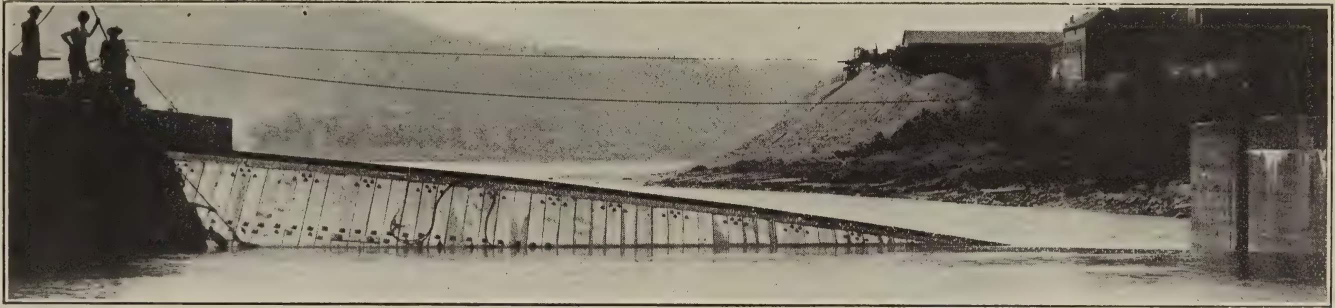


Fig. 15. Same as Fig. 14, except the view is looking downstream.

was raised until its apex was above water. Upon arriving at this position the bottom of the downstream leaf swung away from the quoin, and the dam settled to the bottom. After unwatering the chute, the examination showed that all of the hold-down bolts at the downstream hinge were sheared off and that fifteen of the sixteen hinges at the apex were broken. The beginning of the breaking was undoubtedly due to a piece of steel in some manner getting between the edge of the X-leaf and the steel quoin, in which position the enormous leverage of the weight of the gate caused the nearest bolt to shear off, probably followed successively by the shearing of the other hold-down bolts and the breaking of the top hinges. A description of the break and of the method of repair are given on page 2670, C. of E., 1904. The gate was repaired by replacing the broken parts, using hold-down bolts of twice the cross section of the original.

The operation of this gate was easy, and there was never any indication of a tendency to warp when rising; but the downstream leaf was stiff, and for the short length it could not have been expected to be flexible. No hold-down chain was used on the interior to prevent the gate from rising to the full height permitted by the folding leaf. As a matter of fact, it did rise to full height; but the straightening out of the folding leaf did not interfere with the lowering. The valves in the filling and emptying culverts were operated by water pressure from the city mains. A rather ingenious 5-way valve was used on the supply pipe; and a quarter turn of the lever from the position of ''cut-off'' moved the valves for the connection with upper pool, and a quarter turn in the other direction caused the connection to the downstream pool. If all automatic gates worked as easily and with so few troubles as the one referred to, the type could be regarded as a most successful one.

Provisions for sealing at the upstream hinge was by a small steel plate, hinged just above the main hinge, and resting against the upstream gate in all positions. At the downstream hinge the sealing was provided by a flexible steel plate attached to the bottom of the lower or X-leaf and resting against the hollow quoin. At the junctions of the X and Z leaves and the Z and Y leaves the hinges were designed so as to give as small clearances as possible, and the leakage was inappreciable. At the ends of the dam, provision was made by designing the ends of the X-leaf with a groove of trapezoidal cross section, into which there was placed a steel pipe. The pressure of the water kept the pipe in contact with the face of the abutment, but not so tightly as to interfere with the motion of the gate. The provisions were effective, and there was practically no leakage.

COLBERT SHOALS GATE.

A drawing of this reversed Parker gate is printed in the PROFESSIONAL MEMOIRS, volume VI, number 25, following page 80. Height of crest above hinge of upstream leaf is 8½ feet,

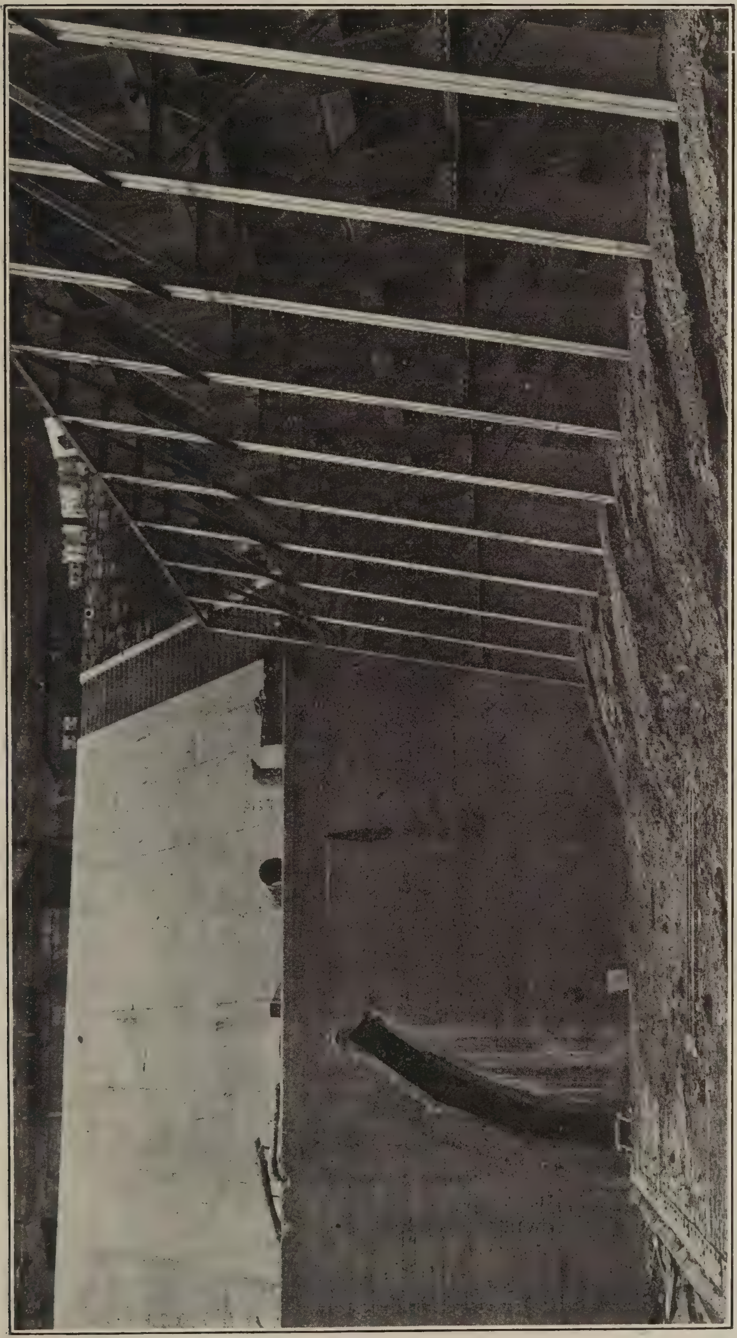


Fig. 16. Pier roller fastened to upper leaf and plates set in pier to form track. Poiree trestles on right. The deposit on the upper leaf which nearly hides it was caused by a small rise in the river which overtopped the Poiree dam.

base measured between hinges is 18¾ feet, and length between abutments is 40 feet. It is of wood with steel fittings, except the Z-leaf which is entirely of steel, made up of separate 12-inch wide plates. There are hold-down chains on the interior to limit the rise, and there is an idler.

The gate was completed in 1909; and in 1911 when water was allowed to enter the canal, it was attempted to operate the gate, but it had to be raised by use of a derrick. During the following night it fell to the lowered position, and could not be again raised. No attempt was made to correct defects until the fall of 1913, when a cofferdam was placed, and the gate was examined. It was found that the most serious defect of construction was that the faces of the abutment, while parallel, were not at right angles to the axes of the hinges, causing binding on downstream leaf at one end and on upstream leaf at the other. It was found also that practically the whole of the idler had been torn away, presumably by drift. The bolts holding the 3-inch by 12-inch timbers of the idler to the steel straps forming the hinged connection to the apex of the gate had been placed too near the end of the timber, the connection failing by the shearing of the wood, the bolts pulling out through the ends.

In making repairs, the abutment faces were chipped until the surfaces against which the ends of the dam rub were at right angles to the line of hinges; and the gate was practically rebuilt, using, however, practically all of the old timbers except those which had been carried away. The cracks between the timbers of the Y-leaf were made tight by the insertion of a ¾-inch by 2-inch tongue in grooves cut in the edges of the timbers. The leaves were increased in length about 3 inches to make up for the concrete which had been chipped away. The new idler timbers were securely attached by the use of long steel straps. Since the repairs were completed the gate operates successfully, except when the head is less than 18 inches; and it could undoubtedly be made to operate with a head of 6 to 9 inches if the leakage through the Z-leaf and at ends of dam was largely reduced, or if the supply culverts were made considerably larger to make up for the leakage. It may be stated, however, that the gate operates in a satisfactory manner; but that its design might be improved by constructing the gate entirely of steel. No tendency to warping has been noticed. Valves are operated by hand through a train of gearing.

ELK RIVER CANAL GATE.

This gate, of direct Parker type, was constructed by Mr. Parker in 1890, was rebuilt from original plans in 1901, and was carried away in 1911, since which time the drift chute has been closed by a timber bulkhead. The gate and abutments were entirely of wood, except for bolts, etc., and for steel rails added to give weight. The height above downstream hinge was 9½ feet, base measured between hinges was 11½ feet, and length between abutments was 40 feet. It may be noted that the base is short compared with the two dams described above, but this shortness of base did not seem to affect the operation of the gate. There was an idler, but no hold-down chains on interior. The valves were operated by hand, with suitable gearing.

The gate was washed away or torn out by drift in January, 1901, and again in January, 1911; in each case, so far as can be ascertained, the failure was due to wearing of the timber near the anchorage of the downstream leaf, permitting the timber to be pulled loose from the hinged-straps.

It is presumed that after one or more of the timbers composing the downstream leaf were torn out, the destruction of the remainder of the gate was rapid. The gate could hardly have been destroyed in this manner if it had been constructed of steel throughout.

So far as can be learned the gate always operated in a very satisfactory manner, the operation being unusually "sensitive." When the water on lower side was above level of the floor of the chute, the gate would not lie flat in its lowered position, doubtless due to its being lighter than the displaced water, but there was always sufficient depth of water over it to permit passing of drift. So far as the operation of the gate was concerned it was a successful structure, but the material composing it was not sufficiently resistant to prevent its destruction.

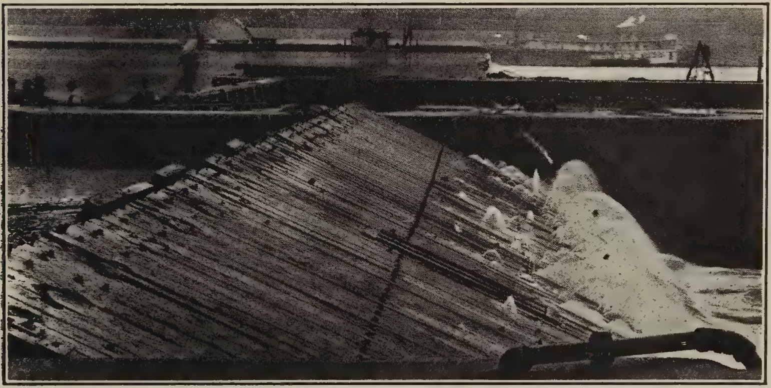


Fig. 17. July 29, 1913. Upper leaf small Parker trap. Highest line of leaf in picture was fastened to the concrete foundation by the upstream line of hinges from which it tore loose. It should be 12 feet below the water surface instead of 3 above it.

REMARKS.

My general conclusion in regard to the Parker gate, either direct or reversed, is that it is a satisfactory type when not too long for the X-leaf to be made stiff enough to prevent warping during raising. From the description of the bear-traps at dam No. 13, Ohio River, and of the trouble experienced with them, I judge that the prime cause of the lack of success was the flexibility of the X-leaf. With a more or less flexible X-leaf it would seem better to arrange the filling culverts so that water could be introduced through a number of openings spaced throughout the length of the chamber, and so that the discharge of these openings could be independently regulated. While this provision might not prevent warped-rising, it ought at least to tend in that direction somewhat more effectively than filling from the ends.

It would seem also that the use of compressed air to aid the rise tends to increase rather than to decrease any initial irregularity of rising, much more in fact than if water pressure alone were relied on for raising the dam. It has always seemed to me that the gate should be designed so that nothing but the water pressure was needed under normal conditions to raise the gate, and that reliance should be on chains and hoisting engines attached to ring bolts when the gate fails to operate. By extensions of the inlet and outlet culverts it would seem possible always to have at least 1 foot head, and this head should be sufficient to operate the gates if the leakage is small. At one time it was proposed, for the purpose of increasing the head for operating the Elk River Parker gate, to install on the X-leaf a small hinged shutter supported, when erect, by props. With this shutter installed, the dam being down, it was expected to pull the shutters by hook-poles into erect position, giving a head at the dam of 3 feet. As the gate came to its raised position, the end of the props would slip from the sockets, and the shutters would fall and lie along the face of the X-leaf. These shutters not being required, were not installed; but I see no reason why this device would not be useful, in some situations, for short *direct* Parker gates.

In view of the success on the Ohio River with the two-leaf bear-trap, and of the failure of the Parker, it would seem to be unwise not to adhere to the former type; but for situations where a short dam is required and where a narrow base is desirable the all-steel Parker, reversed or direct, can undoubtedly be used to advantage.

Mr. F. B. Duis

Assistant Engineer; Member American Society of Civil Engineers

To the writer, who has had as a part of his duties for the last three years the charge of the operating and care of Locks and Dams Nos. 11 and 13, Ohio River, Major Altstaetter's paper is of more than usual interest; especially since the bear-traps at these dams represent exactly the two types considered in the article. The bear-traps at Dam No. 11 are of the two-leaf, steel type, and were, with those at Dam No. 8, the first installed of the latest standard design; and, as mentioned in the paper, the wooden, three-leaf, reversed Parker bear-trap has been installed only at Dam No. 13.

Little more need be said of the two-leaf, steel bear-traps at Dam No. 11 than that they are a complete success so far as their operation is concerned. During the three seasons that these bear-traps have been in use, they have not given the least trouble. In fact, they are more than a success since they can be and have been operated under conditions for which they were not designed, viz, holding them in any position within the limits of their vertical movement. This is accomplished in the following manner: When the bear-traps are held at highest position, which is when its crest is at normal level of upper pool, the valves in conduits leading from chamber under the traps to lower pool are closed and the valves leading to upper pool are entirely open, this giving total pressure under the trap due to head on dam except the small loss from leakage. To hold the traps at intermediate positions between the limits of vertical movement, the inflow of water from upper pool is reduced by means of the valves and so regulated that, with the leakage from the traps, the resultant pressure under the traps is just enough to hold them up without raising them. The amount of opening of the upper valves necessary for this purpose can be determined only by experiment and varies only with the head on the dam. This may seem to be a very delicate operation, but is not, due probably to the considerable friction necessary to overcome in any movement of the bear-trap leaves. Being able to hold the bear-traps at any elevation below upper pool level is a valuable adjunct to its

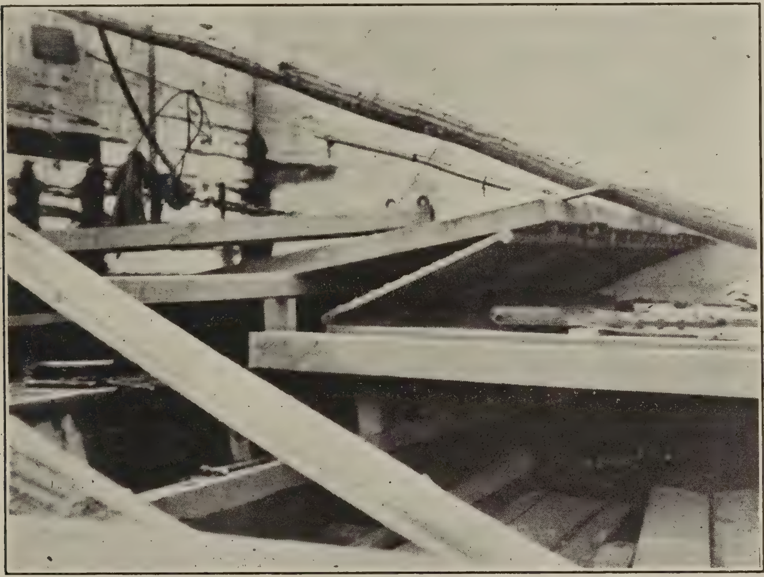


Fig. 18. Reversed Parker trap at Colbert Shoals Canal, showing bear-trap during construction.

usefulness, as in this way the pool level above can be regulated without intermittent raisings and lowerings of the traps. The simple method by which this result is attained can be better appreciated by comparison with the intricate and expensive bear-trap dam built some years ago for regulating the discharge from the Chicago Drainage Canal, where, due to the almost constant discharge, the operations described above would be much easier to accomplish than on the Ohio River with its almost continually varying discharge.

The experiences with the operations of the wooden three-leaf bear-traps at Dam No. 13 may be compared with those of the other type at Dam No. 11 as a pleasant dream to a nightmare. It is doubtful whether any one not fully familiar with the conditions under which the locks and movable dams on the upper Ohio River must be operated, can appreciate the great extent to which the successful and safe operations of these structures depend on the proper working of the bear-trap weirs, and when these act as have those at Dam No. 13, the operating problem is anything but a pleasant proposition. This is accentuated by the numerous requests made by the navigation interests during low-water stages to lower the bear-trap to release water for flushing their boats over bars in the stretches of the river not yet benefited by the slack-water improvements. Inability to give such assistance, due to improper working of the bear-trap weirs, leads to many unpleasant situations, as the navigation interests do not seem to know or want to know of any good reason for not fulfilling all their requests except indifference or incompetence of the officials in responsible charge.

The bear-traps at Dam No. 13 have had this redeeming feature: After each failure and subsequent repairs, they have operated better than before. Since the repairs and improvements made in 1913, they have worked fairly well, coming up without any trouble and warping not enough to either hinder their movement or to cause breakages. This improvement is due mostly to the installation of the rollers on the upstream leaves and which almost wholly prevent the sticking of the leaves against the piers. How long the traps will continue to operate so well is a question. Unless the warping tendencies again increase and more structural weakness of details develop similar to that which caused the last failure, they may last for years, as it was noticed when they were unwatered in 1913 that the condition of the material in the traps was about as good as when first put in five years before.

If nothing more was necessary to be taken into account in the comparison of the two types of bear-traps discussed in Major Altstaetter's paper, there would be no object in future design and construction of bear-traps in the Ohio River to consider any departure from the present standard two-leaf steel type, since it is reasonable in first cost and meets every requirement for operation. But whether the type is economical in cost, when its durability is considered is not yet definitely known. The destructive effects during low-water periods of the acids coming into the upper Ohio River from the mines and mills, has already become a serious problem in the maintenance of steel work in the river. The amount of acids coming into the river is constantly on the increase and unless some preventive measures are employed soon by the Federal authorities to whom this question has already been referred, the maintenance of steel structures in the river may become a very expensive proposition. In such a case it may yet be necessary to give more consideration to a type of bear-trap from the standpoint of durability. In the present standard two-leaf type, the downstream leaf, the one in which the rigidity is required, is entirely of steel, the minimum thickness of the steel being ⅜ inch. The life of the structure could be increased by using thicker plates, but the increased weight would require greater head of water for raising, and this would be objectionable. The problem might be met by substituting a wood decking for the present steel skin plates. These steel plates undoubtedly add some rigidity to the leaf, but it is not certain that they are necessary for this purpose due to the strong cellular structure formed by the girders running in each direction. The weight of steel in the skin plates could then be added to the girders, as the wood decking would add no weight to the trap while in water and no greater head of water would be necessary for raising the traps. That a downstream leaf of this type was used in the bear-traps at Dam No. 6, Ohio River, and found not a success does not prove the impracticability of the type, as the girder construction in those leaves is much weaker in resisting warping than in the present standard design. The great width of these leaves (120 feet) also greatly increases the warping tendency over the present standard width of 91 feet. The writer does not wish to be understood as advocating the consideration at the present time of wood decking and heavier steel girders for the lower leaf, but presents it only as a possible solution, should some change in design of the bear traps become necessary on account of the impermanence of steel.

It has long been known that wood construction for the main members of the downstream leaves is entirely impracticable for two-leaf bear-traps of the size used on the Ohio River, on account of the warping tendencies. The objections to the all-steel leaves, for the reasons previously mentioned, are also not of recent origin. The belief that both of these problems could be met by the wooden, three-leaf, reversed Parker type of bear-trap, and also the economy in cost, were the main reasons, in my opinion, that led to the adoption of this type for the bear-traps at Dam No. 13, Ohio River, though my opinion in this particular is not based on actual knowledge of the facts. The failure of these traps to come up to the things expected of them, though expensive and the cause of considerable worry and trouble, has been valuable engineering experience and the money expended for it is not entirely wasted. Consideration must be given to the fact that at the time the bear-traps at Dam No. 13 were designed, the present standard and perfected two-leaf type was yet in its evolution as none had then been constructed and operated; and also that its final perfection was the result of about twenty-five years of experimenting.

Though the present bear-traps at Dam No. 13 have proven to be a failure, it is not a just trial of the reversed Parker type of that size. As is stated in Major Altstaetter's paper, the foundations for these traps were designed and built for the two-leaf type, and due to this the distance between the two lines of hinges by which the traps are held to foundation is much greater than necessary and desirable for the three-leaf type. For the bear-trap having the 15-foot vertical lift, the distance between these hinges is 49 feet; while, if the foundations had been designed and built for the type of trap built on it, this distance would probably have been not over two-thirds that amount and would have been a considerable saving in cost of foundation. The leaves, also, would then have been much shorter, especially the downstream one. This would have further reduced the cost of the structure. There is also no doubt, in my opinion, that the shorter leaves would have resulted in the traps working a great deal more satisfactorily, as the warping tendencies should have been greatly reduced. These statements are not to be construed as advocating the building of any more bear-traps of this type in the Ohio River, even though correctly designed. It is not believed that the type can be made with as much success for that size and kind of construction as the two-leaf steel type with its more simple design. The only reason that should warrant a radical change in design from the present standard bear-traps in the Ohio River dams is the possible short life of the steel that is the necessary material for the two-leaf type.

Maj. Gen. Montgomery Cunningham Meigs*

BY

First Lieut. B. C. Dunn
Corps of Engineers

General Montgomery Cunningham Meigs was born in Augusta, Ga., May 3, 1816; his parents, Dr. Charles D. Meigs and his mother, Mary, moved with him when he was thirteen months old to Philadelphia, Pa., in 1817. He entered the United States Military Academy July 1, 1832, and graduated July 1, 1836, standing 5 in his class. He was made a Second Lieutenant in the First Artillery, but resigned July 31, 1837. The day following he was made Brevet Second Lieutenant, Corps of Engineers, to rank from date of graduation; was promoted First Lieutenant Engineers July 7,1838, and Captain Engineers March 3, 1853.

Up to 1861, as Lieutenant and Captain of Engineers, he was engaged in the building of Fort Delaware, in the improvement of the Harbor, improvement of Delaware Bay, and as Superintending Engineer in the construction of Forts Wayne, Porter, Niagara, Ontario, and Montgomery. He had charge of harbor improvements in Delaware Bay and on the New Jersey Coast, the Washington Aqueduct, and superintended the building of the new wings and dome of the National Capitol Extension; the extension of the General Post Office and the completion of Fort Madison, Maryland.

On the inauguration of President Lincoln, in March, 1861, he was directed by him to prepare a project for the relief of Fort Pickens, then in imminent peril, and as engineer accompanied that expedition to its successful completion.

He was appointed Colonel, Eleventh United States Infantry, May 14, 1861, and on May 15, 1861, was appointed Quartermaster-General, United States Army, with the rank of Brigadier-General, which position he held until February 6, 1882, upon which date he was retired

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*See frontispiece.

He was brevetted Major-General, United States Army, July 5, 1864, for distinguished and meritorious services. During the war he was engaged in equipping and supplying the armies in the field from May 15, 1861, to August 12, 1866, and was present at several of the important battles of the war.

After the war he performed various important duties. He visited Europe in 1865 and 1866, on special service to study the construction and government of European armies. He was a member of the Commission for the Reform and Reorganization of the Army and for devising a project for a new building for the National Museum, and a member of the Army Regulation Board.

As Captain of Engineers, he constructed public works costing over ten millions of dollars and as Quartermaster-General he directed the use and application of appropriations entrusted to him amounting to ninteen hundred and fifty-six millions.

After his retirement in 1882 he was architect of the building for the Pension Bureau, Regent of the Smithsonian Institute and Fellow of the National Academy of Sciences.

He died at Washington, D. C., January 2, 1892, aged seventy-six years.

In a document published May 28, 1867, ex-Secretary of State William H. Seward, states as follows concerning General Meigs: "The prevailing opinion of this country sustains a firm conviction which I entertain and on all occasions cheerfully express, that without the services of that eminent soldier, the National cause must either have been lost or deeply imperiled in the late Civil War."

Personally, General Meigs was a man of kind and amiable character, of strict probity and sense of right, and of great breadth of intellect. The Army has rarely possessed an officer who combined within himself so many and valuable attainments, and who was entrusted by the Government with a greater variety of weighty responsibilities; or who has proved himself more worthy of confidence. There are few whose character and career can be more justly commended, or whose lives are more worthy of respect, admiration and emulation.

The Work of the Army in the Construction and Maintenance of Roads*

It is a well-known saying that an army marches on its stomach, but it is perhaps not so generally recognized by the layman that the keeping of that stomach in a proper condition for marching—in other words, the keeping up of the efficiency of the army—is largely a question of roads. It is indeed possible for troops to march through a country without roads, through dense forests, across bridgeless streams, over pathless mountains, and small bodies of troops have many times been compelled to overcome just such natural obstacles. So great, however, is the difficulty of supply in such cases that a campaign in a section without roads is never undertaken unless there is no other way of achieving the result sought or unless the advantages to be gained are enormous; even then, if the body of troops to be moved is large, or if the results of the campaign are to be lasting, the building of roads will be one of its most important features.

In the case of great wars, however, which are usually carried on in civilized lands, the roads are one of the most important of all the factors to be considered and no one is more interested than the soldier in the maintenance of good roads throughout the country. In these modern days the railroads, as the main arteries of supply and transportation, are the first roads to be taken into account, but the country highways and byways in the actual field of operations have lost none of their old-time importance. The leaders of the army must have a thorough knowledge of every one of them, while the engineers of the army must be ready to open up roads that the passage of the army or the operations of the enemy have rendered impassable, to maintain the good roads in good condition, to improve the bad roads, and to build new roads if necessary.

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*Address delivered before the American Road Congress in Atlantic City on October 4, 1912, by Col. Spencer Cosby, Major, Corps of Engineers; M. Am. Soc. C. E.

MILITARY ROADS IN OTHER LANDS.

From the earliest times the soldier has been intimately associated with the making of roads. The school boy still struggles with the description of the roads built by the armies of Xerxes and Hannibal. The famous old paved Roman roads, remains of which are to-day found in many parts of Europe, some still in use, were essentially military roads, while the greatest soldier of modern times, Napoleon, was also one of the greatest road builders. He it is that France has to thank for its system of magnificent highways, which were built for military purposes and are still kept up by the government largely with this end in view.

ROADS IN THE UNITED STATES.

In our country, however, the Army has been concerned not only with the construction and maintenance of roads as a military necessity—and we all know of its struggles with the fearful dirt roads of old Virginia during the Civil War—but it has had and still has much to do with the building and upkeep of roads not strictly military in many parts of the United States and its recently acquired outlying possessions. During the early days of the Republic the graduates of West Point were, except for a few foreign engineers, practically the only men in the country who had a thorough technical training. They not only surveyed and mapped a large part of the unexplored west, but laid out and built most of the first railroads in this country as well as in Russia, Cuba, and Mexico. It was but natural that they should be largely employed in such work of road building as was engaged in by the General Government. Most of the members and assistants of the Board of Engineers, created by Act of Congress in 1824, were army officers; one of the chief duties of this Board was the making of surveys, plans, and estimates for such roads as the President might ''deem of National importance in a commercial or military point of view, or necessary for the transportation of the public mail.'' The Board was placed under the Engineer Department of the Army.

The question of the constitutional power of the Government to build roads and of the general policy to be pursued in this respect was one of the burning questions of the day between 1805 and the end of the thirties; it was the subject of many congressional reports, of at least three presidential vetoes, of several presidential messages, and of important judicial decisions. Since the last large appropriation for the Cumberland Road was made in 1838, the

Government has practically confined its road building in the United States proper to military roads, and those built on land under the control of the Government.

THE CUMBERLAND ROAD.

In 1806 the Government undertook the construction of the famous old "National" or Cumberland Road, as it came to be known; it was originally intended to extend from tidewater on the Atlantic Ocean to the Ohio River, but it went much farther; it was actually completed from Cumberland, Md., through the states of Maryland, Pennsylvania, West Virginia and Ohio, to Springfield, O., and partly built from there to Vandalia, Ill., a total distance of 591 miles. Subsequently it was donated to the States through which it passes. Congress appropriated in all nearly seven million dollars for its construction and maintenance, and the services of many graduates of the Military Academy were employed in the work. The road-bed was cleared over a width of 80 feet, but only 30 feet of this was covered with stone. It was the longest stone road ever built by our Government; in fact, I know of no longer stretch of metalled road built by a single agency in the United States.

The work of clearing the ground for the road actually begun in 1808, but the first contract for construction was not let until 1811. The eastern section was built under direction of the Treasury Department at a cost of $1,702,000; in 1824 the practice was begun of using military experts in the construction of the road, which was formally placed under the direction of the War Department in 1827; this Department continued in control until the last section of the road was surrendered to the individual States in 1856. It was soon after the Army took charge that the macadam system was regularly and scientifically adopted for the construction and repair of the road. Prior to that time it had been built by digging a trench, so as to sink the bed below the natural surface of the ground; this trench was filled with large stones, these were covered with stones of a smaller size, and these in turn with gravel. This system made drainage difficult and the road deteriorated rapidly; in a report made in 1832 the old Maryland section of the road is stated to be "in a shocking condition," some of it "almost impassable." The road was rebuilt by macadamizing it over the old bed, great attention being paid to the proper location and construction of ditches and culverts.

The Cumberland Road, as finally completed by the Army engineers, exemplified the application of the best principles of road building known in its day and was the most important, as well as one of the first, modern roads in this country. It represented a big advance over the methods used in constructing the early State turnpikes, on which many millions had been expended. The road, with its ponderous stone bridges and culverts, is still in use and it is said that in many places the old macadamized bed is still doing duty.

OTHER GOVERNMENT ROADS.

While the Cumberland Road was building, the Army was engaged in the construction of many military roads in the west and south, chiefly for the purpose of enabling supplies to be hauled by wagon to the advanced military posts. Many of these roads were built by the troops themselves under the direction of their officers, and were generally constructed in the simplest possible manner that would permit the passage of the rough wagons of the day. As the country became settled, the traffic over many of these highways became so heavy that in parts at least they were improved both as to location and character of road surface. Examples of these early military roads are that from Detroit, Mich., to the Maumee River, built by Maj. John Anderson in 1817; the military road from the Tennessee River to New Orleans begun in 1816; the military road through Mississippi built in 1819-1820; the roads in Florida to St. Augustine and from the Georgia State line to Smyrna, Fla., constructed between 1824 and 1830; and those in Arkansas to Little Rock, and from Fort Leavenworth, Kans., to Fort Smith, Ark., built by the Infantry in 1837-1838.

From 1824 to 1838, Congress made extensive appropriations for roads in various parts of the United States; after 1838 a few small appropriations were made from time to time; all these roads were built under the direction of the Army. At first they were constructed partly by the Quartermaster's Department, and partly by the Engineer Department, but after a few years all road work except at Army Posts was transferred to the Engineers. The nature of these early roads can be imagined from the fact that in December, 1828, the Quartermaster-General reported to Congress that in the preceding four and one-half years his Department had completed 1,456 miles of roads in Florida, Georgia, Arkansas, and Louisiana at a total cost of $77,077, not quite $54 a mile. Some of these roads must have been wonders, as, for instance, the one reported completed from Pensacola, Fla., to Fort Mitchell, Ga., 233 miles at an expense of $1,138, almost $5 a mile. I can find nothing done by the Engineers to equal this record, though they do report a road built in New Mexico, 300 miles long, at a cost of $40 a mile. The employment of troops in the construction undoubtedly cut down the cost in many cases. The most important road built by the Quartermaster's Department was apparently a military road in the northeastern part of Maine, 95 miles long, built between 1828 and 1834 at a cost of $137,000.

The roads built by the Engineer Department were mostly of a primitive character; prior to 1860 the number of roads reported as having been surveyed and constructed, improved or completed by them was 57, having an aggregate length of 6,583 miles and costing in all $1,920,000, thus averaging a little over $291 per mile. These roads were built in the States of Alabama, Arkansas, Florida, Iowa, Idaho, Illinois, Indiana, Kansas, Michigan, Minnesota,Montana,Nebraska, New Mexico, Oregon, Washington, and Wisconsin. The most important was the road which was to run from Memphis to Little Rock and which was actually constructed as far as the St. Francis River at a cost of over $6,000 a mile; the road from Detroit to Chicago, 263 miles, costing $88,900; a road from Point Douglass to the mouth of the St. Louis River, to connect the head of navigation of the Mississippi River with Lake Superior, 173½ miles, costing $120,600; from Omaha to Fort Kearney, Nebraska, 168 miles, costing $50,000; from Santa Fé to Taos, N. M., 73 miles, costing $51,000; from Scottsburg to Myrtle Creek and Camp Stuart, Ore., 160 miles, costing $109,300; and the Mullan Road from Fort Benton on the Missouri River in Montana to Walla Walla, Wash., 624 miles, costing $200,000.

The 57 roads mentioned do not include the Cumberland Road, on which the Government spent an average of over $10,000 per mile, nor the trail opened by the Engineers in 1854 from Salt Lake City to the eastern boundary of California, a distance of over 600 miles at a cost of $25,000.

Of the fifty-seven roads built by the Army Engineers, some were purely military in character and others partly so, but many were intended to open up communication with newly developed territory, to induce the sale of public lands, and to facilitate emigration and the transportation of the mails. None of these roads, with possibly one exception, were, I believe, metalled. The character of the construction is indicated in the following extract from a report made in 1840 by the Chief Engineer in charge of the works:

> I have not considered the obligation of the Government in reference to these roads, to involve more than what is understood by the ''opening of a road,'' or the construction of one on the most simple principles; that is, that the timber should be cut down and removed, the undergrowth grubbed up and removed, ditches dug on the sides of the road where required, swamps made passable by the customary log structures, and bridges thrown over streams that are not conveniently fordable, leaving all artificial structures of a road-bed to the future efforts of the local authorities, or to positive legal enactments by the General Government.

THE OLD SANTA FE TRAIL.

Another famous highway with which the Army was long and intimately associated was the old Santa Fé trail, extending from Fort Leavenworth, Kans., to Santa Fe, N. M. In its palmy days the travel over it was large and important, but as far as I have been able to ascertain, no great amount of road work was done upon it by the Army or anyone else. Travelers were far more concerned with the ever present danger of attack by Indians than with the condition of the roadbed, and to guard and defend travel on the old Trail was long one of the arduous duties of our Army in the West. The main line of the Atchison, Topeka, and Santa Fe Railroad closely follows the old Trail in many places.

WAYNE'S TRACE.

Many thousands of miles of the main highways in the fertile states west of the Ohio are, so to speak, the lineal descendants of the trails and roads first broken through the wilderness by the Army in its numerous explorations and in its expeditions against hostile Indians. The precursor of all of these was the road known as Wayne's Trace, cut by Gen. Anthony Wayne through the forests of Ohio and Indiana during his Indian campaign of 1794. It began at what is now called, I believe, ''Mad Anthony Street'' in Cincinnati, and extended northward through the present towns of Hamilton, Greenville, Fort Recovery, and Defiance, to Maumee, where the decisive victory of Fallen Timber was won. From there the road was extended to Fort Wayne, named in honor of the victorious general.

EXPLORATIONS.

The earliest knowledge of much of our western country and the location of the first routes of travel were largely the result of military explorations and reconnaissance work from 1800 to 1880. Some of the most notable expeditions were those of Captains Lewis and Clarke, 1804 to 1806, to the sources of the Missouri and down the Columbia to its mouth; of Lieutenant Pike, 1805-1807, to the sources of the Mississippi and Arkansas; of Captain Bonneville, 1832-1836, to Great Salt Lake and the region west of the Rocky Mountains; and of Capt. J. C. Fremont, 1842 to 1846, during which he mapped the road from the Missouri River to Oregon, and explored upper California and Oregon. From 1845 to 1861 many other Army officers were detailed to continue these explorations and to locate military roads in the western wilds. Among the officers actively engaged on this work were Lt. Col. Joseph E. Johnston, Capt. George B. McClellan, and Lieut. G. K. Warren, who a few years later became distinguished generals in the Civil War.

During that war the Engineer troops were, among other duties, extensively employed in building and repairing roads in connection with the campaign in Virginia. The usual method of repairing the old dirt roads in important cases was to corduroy them; this generally consisted in laying a number of stout sill timbers lengthwise and placing transversely over them saplings 4 to 6 inches in diameter, tied down by side rails, which were in turn anchored by pickets. Many hundreds of miles of these roads were built during the war.

As soon as the war was over, the Army resumed on a more extensive scale than ever its work of exploration and of survey in the West. In addition to the many large expeditions set out, small detachments of Engineer troops were employed on reconnaissance work throughout the west under the direction of Engineer officers; it is recorded in the annual report of the Chief of Engineers for 1876 that the enlisted men in the West during three years reconnoitered and mapped 24,044 miles of routes traversed by scouting parties and expeditions against hostile Indians.

ROADS IN NATIONAL PARKS.

In the numerous areas of land owned by the Government throughout the United States, such as military posts and reservations, national cemeteries, sites of river and harbor works, and national parks the Army has built hundreds of miles of good roads. The most extensive of these systems is probably that in the Yellowstone National Park, comprising a total mileage of some 345 miles. These roads were built by the Army Engineers who spent about two million dollars in their construction, maintenance and repair. Most of the roads are metalled, and though they can not be considered as roads of the first class as yet, they are fully as good as the amounts appropriated by Congress (averaging about $3,000 per mile for construction) would permit. They are well located and well drained, and many great natural obstacles have been overcome in building them through a difficult mountain region. Plans and estimates have been prepared by the War Department for the improvement of these roads in accordance with the best principles of modern practice, as soon as Congress provides the necessary funds. A road 25 miles long has been built by the Army Engineers in the last eight years leading into the Mount Rainier National Park at a cost of about $250,000.

ROADS IN THE DISTRICT OF COLUMBIA.

Since 1874 all street and road work in the District of Columbia has been under the charge of officers of the Corps of Engineers. The present condition of the city streets and suburban and park roads give evidence of the faithfulness with which this charge has been exercised.

A description of the road building activities of our Army would not be complete without a brief reference to the work done by it in recent years in lands beyond the sea.

IN CUBA.

During the period of the first American intervention in Cuba, just after the Spanish War, the road work under the Army was confined chiefly to making passable the existing roads and bridges which had suffered severely during the preceding years of revolution.

At the time of the second military occupation of Cuba, the Americans found only 380 miles of improved roads in an island the area of which is 41,000 square miles. The adjacent island of Jamaica, one-fifth the size, had over 6,000 miles of such roads. The unimproved roads in Cuba hardly deserved the name; transportation over them was costly and slow, being carried on by means of pack trains and two-wheeled carts, and the latter often found the roads impassable. In the two years of American intervention, from 1907 to 1909, in addition to extensive repairs made to the existing roads over 460 miles of new roads were either completed or well advanced towards completion. This work was done under the Department of Public Works, at the head of which was an Engineer officer of the United States Army, and some of it was done under the direct charge of Engineer troops. The roads were all macadamized for a width of 16 feet and given a maximum grade of 6 per cent.

IN THE PHILIPPINES.

During the first two years of their occupation of the Philippines the Americans had their hands full in fighting the insurgents, but even then the Army did considerable work in the repair and maintenance of roads and bridges in the course of its operations. In 1900, however, before the fighting was fully over, detachments of Engineer troops were sent to various parts of the Islands, charged with the repair of roads and bridges; the number of these detachments was increased during the following year and many hundreds of miles of roads were repaired, and in numbers of cases entirely rebuilt. During the course of this work one officer was killed and one captured by the insurgents.

The first act passed by the United States Philippine Commission appropriated one million dollars from Insular funds for the repair of roads and bridges. This work was placed under the Army Engineers. Other large appropriations were subsequently made, and much of the work, especially in the beginning, was executed under the direction of Army officers. Even now they still have charge of the work in the Moro Province.

IN PORTO RICO.

During the nearly four centuries of Spanish rule in Porto Rico, only 158 miles of permanent roads had been constructed in the island. During the two years of American military government immediately following the war, $155,000 was spent in the repair and maintenance of these old roads, and about a million and a half was expended or contracted for in the construction of 123 miles of new roads.

IN ALASKA.

It is a long leap from the tropics to Alaska, but there, too, our Army has in recent years been actively engaged in road building. Congress has placed ''the location, laying out, construction and maintenance'' of roads in the Territory under a Board of three Army officers. Their last report showed 800 miles of wagon roads, 534 miles of winter sled roads, and 1,100 miles of trails constructed. The best of these, the wagon roads, are in the main only dirt roads, but they are serving well their purpose of rendering habitable a vast country hitherto almost inacessible.

In the limited time available for the preparation of this paper, I feel that I have not been able to do full justice to the subject, and some inaccuracies may have crept in, though most of my statements are based on official records.

While the Army has always kept in touch with the most approved methods of road construction and has done its share toward the development of those methods, the most notable road work of the Army has been that of the pioneer in the vanguard of civilization, exploring and opening up routes where no roads existed, making possible the advance into the wilderness of the great army of settlers. They and their sons converted the rough early trails into the roads of to-day and multiplied them exceedingly. It is for us, their grandsons, to continue worthily the work they begun, to convert our heritage of rough country roads into a nation-wide system of modern highways, fully equal to those in older lands, and capable of carrying in all weathers, quickly and at little cost, the rapidly increasing traffic that is pouring over them.

Damage to Lining of Filling Tunnel, Poe Lock, St. Marys Falls Canal

BY

Lieut. Col. MASON M. PATRICK
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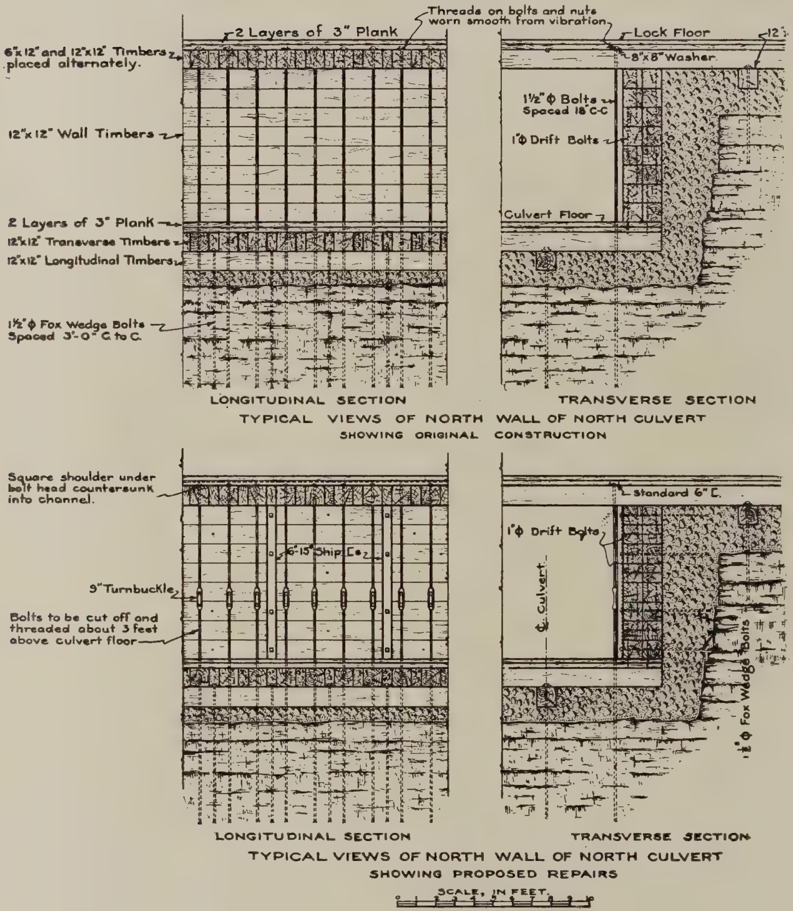
When the annual examination of the St. Marys Falls locks was made after the close of the navigation season of 1913, it was found that some damage had occurred in the north filling tunnel of the Poe Lock at its upper end. There are six of these filling tunnels, each 8 feet by 8 feet, passing through the miter wall of the upper lock gate and under the floor of the lock with openings through the floor. The two outside tunnels extend to about the middle of the lock. The upper end of each tunnel is closed by a butterfly valve. The sides of the tunnels are 2 feet thick, made by bolting 12-inch square timbers one on top of the other. The lock floor over tunnels is held down by long 1½-inch fox wedged bolts extending from the transverse timbers in the floor through the tunnels about 6 inches from the side walls and about 6 feet into the rock. These bolts are subject to considerable vibration which has loosened the nuts and in many cases there are no vestiges of the threads on the portions of the bolts which the nuts occupied. Such bolts are repaired by cutting off the top halves, replacing them by half lengths having heads on their upper ends and connected with the lower halves by turnbuckles.

The tunnel lining is flush with the masonry of the piers of the miter wall. The timbers in each layer of this lining are drift-bolted together, but the two layers are not connected nor were the linings of the outer tunnels anchored to the masonry behind them. When the north tunnel was entered at its lower end for the usual inspection a short time ago, there was found a confused mass of 12 inch by 12 inch timbers, evidently at one time part of the tunnel lining. The photographs illustrate what had happened. The inner layer of this tunnel lining for about 20 feet from its upper end had been torn from its place and much of it had been swept down to the lower end. Some few timbers, as shown in the photograph, had


Threads on bolts and nuts worn smooth from vibration
2 Layers of 3" Plank
6"x12" and 12"x12" Timbers placed alternately.
12"x12" Wall Timbers
2 Layers of 3" Plank
12"x12" Transverse Timbers
12"x12" Longitudinal Timbers
1½" ϕ Fox Wedge Bolts Spaced 3'-0" C. to C.
Lock Floor
12"
8"x8" Washer
1½" ϕ Bolts Spaced 18" C-C
1" ϕ Drift Bolts
Culvert Floor
Square shoulder under bolt head countersunk into channel.
6-15" Ship [s
9" Turnbuckle
Bolts to be cut off and threaded about 3 feet above culvert floor
Standard 6" [.
1" ϕ Drift Bolts
℄ Culvert
1½" ϕ Fox Wedge Bolts
SCALE, IN FEET.
0 1 2 3 4 5 6 7 8 9 10

LONGITUDINAL SECTION TRANSVERSE SECTION
TYPICAL VIEWS OF NORTH WALL OF NORTH CULVERT
SHOWING ORIGINAL CONSTRUCTION

LONGITUDINAL SECTION TRANSVERSE SECTION
TYPICAL VIEWS OF NORTH WALL OF NORTH CULVERT
SHOWING PROPOSED REPAIRS

Fig. 1. Filling tunnel at Poe Lock, St. Marys Falls Canal.

been displaced, but had not been entirely detached. The fox wedged bolts, which it will be remembered had extended through this tunnel about 6 inches from the lining, had been broken and bent as shown. For a further distance of 100 feet this outer layer of the lining had been bowed out sufficiently to bend these long bolts.

The inner layer of the lining seems to have been undisturbed. Where the outer layer has been torn away, there is no evidence that the inner layer has been moved at all.

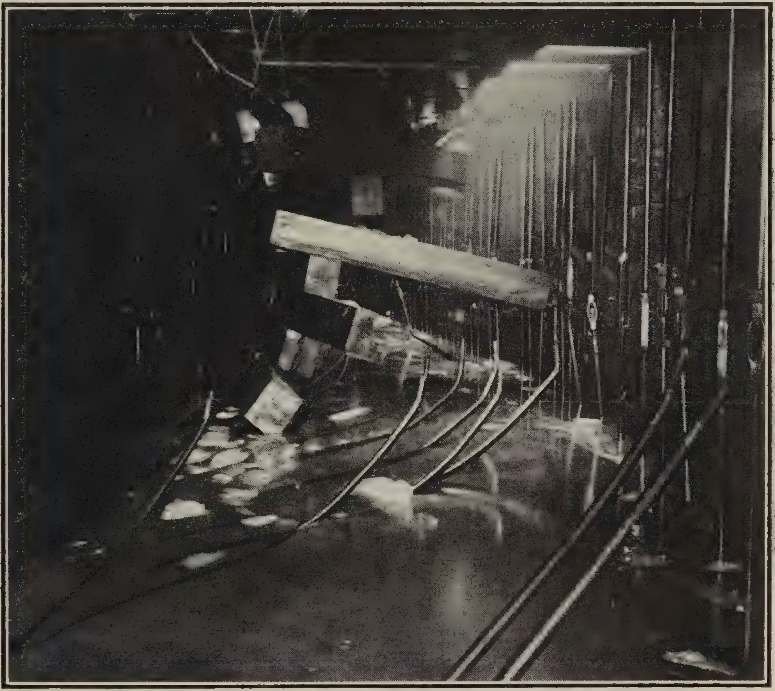


Fig. 2. St. Marys Falls Canal, Poe Lock. Damage to north filling culvert, looking east from point under miter wall at 3345 East, showing broken timber of north wall, January 8, 1914.

Evidently the inrushing water found its way between the two layers and separated them as above, tearing out the outer layer for a portion of its length.

It is proposed to repair this damage by replacing the timbers torn out, placing along their inner faces at proper intervals vertical channels held in place by fox wedged bolts extending through both layers of the lining and into the masonry behind them. Where these timbers are bowed out, they will be jacked back into place and secured by channels in the same manner. This method is cheaper than the substitution of concrete for the timber tunnel lining .

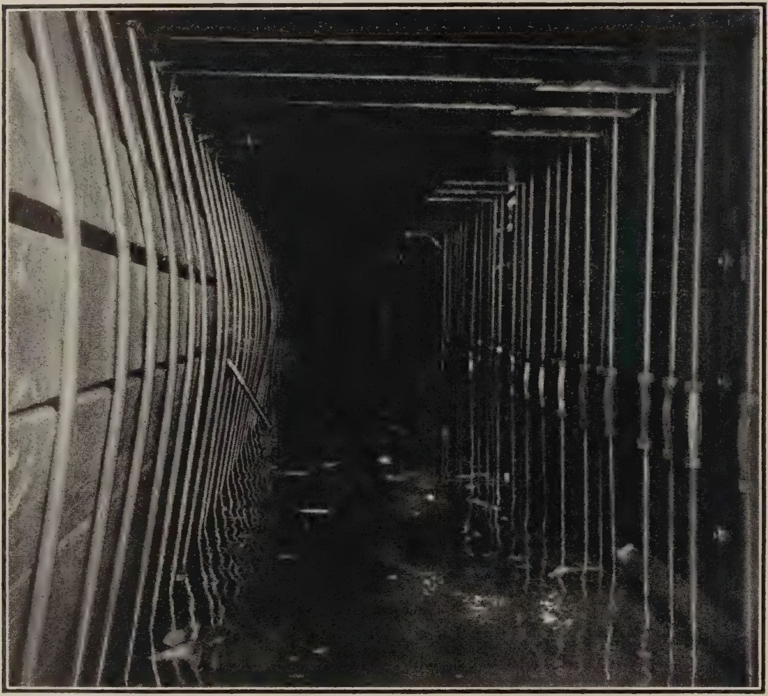


Fig. 3. St. Marys Falls Canal, Poe Lock. Damage to north filling culvert, looking east 3373 East, showing partial failure of north wall, January 8, 1914.

Repairing Leaks in an 8-inch Water Main 40 Feet Under Water in Galveston Harbor, Texas

BY

Mr. N. T. Blackburn
Junior Engineer

About two years ago a water main of 8-inch cast iron pipe with lead calked flexible joints was laid across Galveston Channel, which is the waterway lying along the wharf front of Galveston. It extended from the wharf front, where it connected with the city water main, to the pile dike on the north side of the channel, a distance of 1,400 feet, thence was laid in a shallow trench along the dredge spoil bank to the Government Immigration Station. The portion across the channel was laid in a trench 40 to 100 feet wide, dredged to a depth of 41 feet across the entire width of the Galveston Channel, which was then about 30 feet deep for 500 feet of its 1,400 feet width. Cast iron pipe was used with flexible joints of the ordinary ball-and-socket type, which allow a deviation from a straight line of about 12 degrees. The ordinary lead calking was used with yarn packing. The greater portion of the line was laid by calking up and lowering one pipe at a time, the line of pipe being carried on an inclined trough from the barge nearby to the bottom of the trench and the barge being fleeted forward as the line lengthened. Soon after the laying was completed and water had been turned into the main, leaks began to develop due partly to the method of laying and to the uneven character of the bottom, which caused such a great deflection at each joint that the lead calking was squeezed out, and to the fact that the line was caught by a ship's anchor before completion. Efforts were made to recalk the leaky joints by the aid of a diver, but these efforts were unsuccessful as it was found the pipe was deflected at these points to such an extent as to close the calking space on two sides. After considerable thought and investigation, a method of stopping the leaks was evolved which has proven entirely successful. It is the purpose of this paper to describe this method.

The method was simply the placing of a wooden box form around each joint and filling this form with neat Portland cement grout. Each form was supported on three 3-inch pipe, 14 feet long, driven down through holes in the forms into the underlying clay so as to form a pile foundation and prevent any settlement at the joint due to extra weight.

The form is shown in detail by the three drawings and the photographs accompanying. It is 3 feet 4 inches square by 2 feet deep, hinged at one edge so that it opens diagonally. In the top is a 4-inch hole with a pipe flange for connecting a 4-inch pipe extending to the top of the water, as shown on the sketch, and through which the grout was poured from the barge into the form. To the front of the lower half was fastened a chain which helped close it and held it closed afterwards, one link being let over a hook attached to the upper half and screwed up until form closed tight. In either side, where main passed through, a square hole 18 inches by 18 inches was left in order that the form would close no matter if the joining pipes were at their greatest possible angle, either vertical or horizontal. A movable section consisting of two pieces, 2 inches by 12 inches by 3 feet, each cut out in the form of an 8-inch semi-circle to take half of the main, closed around the main

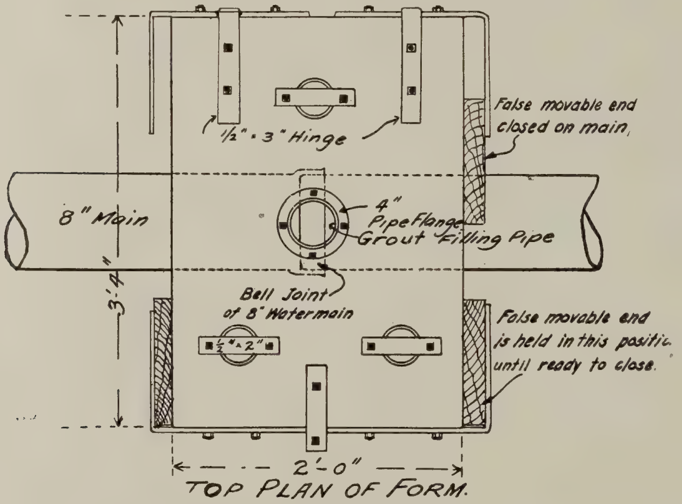

½" • 3" Hinge
False movable end
closed on main,
8" Main
4"
Pipe Flange
Grout Filling Pipe
Bell Joint
of 8" Watermain
½" × 2"
3'-4"
False movable end
is held in this positi
until ready to close.
2'-0"
TOP PLAN OF FORM.

Fig. 1. Form used in repairing water main.

tightly covering and at the same time entirely closing the 18-inch square holes. These false ends work outside of the form and are held in position by iron straps under which they can move in any direction against its side. Three holes large enough to take 3-inch pipe were bored through the top and bottom of the form for the piling. They were so bored that two piles would go on one side of the main and one on the other. After the pipe piles were driven down through the form flush with the top, a one-half inch iron plate was laid over the top of the pile and bolted to the form to carry the weight until the cement set around the piling.

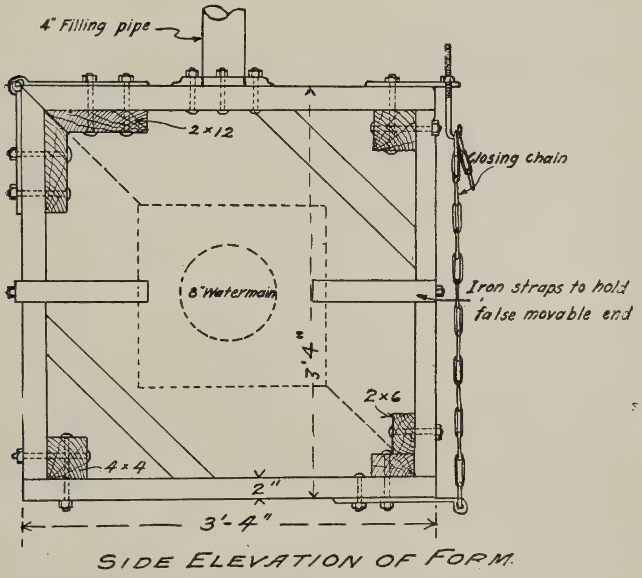


Fig. 2. Form used in repairing water main.

The trench in which the main lies had been partly refilled with clay thrown into it by a dredge and by the natural deposit of sand, mud, and silt carried in by the cross currents and tides. This filling was partly removed with a 20-inch suction dredge, but fear of disturbing the main kept the dredge from working closer than about 4 feet of its top. After the dredging was done the water was cut off the main, air pressure put on and leaks were located by the air bubbles coming to the surface of the water. All leaks of any consequence were marked by dropping a weight into the hole blown through the mud over a leak by the air and carrying a line ashore from the weight. It was not safe to use buoys for marking the leaks, as they were liable to be carried away by ships and all leaks had to be located and marked before repairs were commenced as the air pressure had to be taken off the line and kept off until the cement was thoroughly set.

The plant used consisted of a derrick barge and a barge with an 8-inch belt-driven sand pump. A diver was in constant attendance.

The method of placing the form and filling with grout was as follows: The barges were anchored at the leak and the overlying sand and mud first pumped off the pipe. Then to the flange coupling on the form was connected a 45-foot length of 4-inch pipe. Three rope lines were fastened to the front of the lower jaw of the form, one to the end of the closing chain and one near each side. The diver then took all three of these lines down around under the main and back up on the barge where a man was stationed at each line. Then as the form was lowered away by the derrick with a line from the 4-inch pipe, the men took in on these lines and the lower half of the form, which dropped open when the form was picked up, was guided into place under the main.

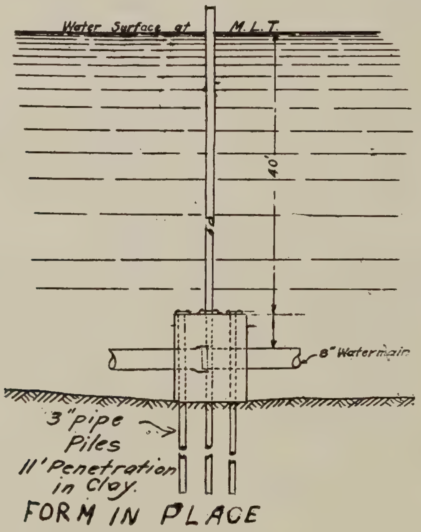


Fig. 3. Form used in repairing water main.

By lowering the upper half the form was closed. The piling were then set in the holes provided in the form and were driven flush with the top and the iron straps bolted over them. A jet was then put into the form through the 18-inch square openings and any mud in the form driven out and the joint thoroughly washed off. A piece of raveled, loose rope yarn was then tied securely around the leak to keep the cement from entering the main. The false forms over the ends of the form were then driven into place around the pipe and the form was ready for cement. The cement was mixed with salt water to a thickness that would just pour through a funnel into the 4-inch pipe leading down into the form. It was found necessary to pour it slowly in order to give it time to settle. Displaced water went out of the form through the holes around the piling in the top of the form. When the form was filled, the nuts on the bolts in the flange union fastened to the form were taken off and the 4-inch filling pipe removed, and the job was finished.

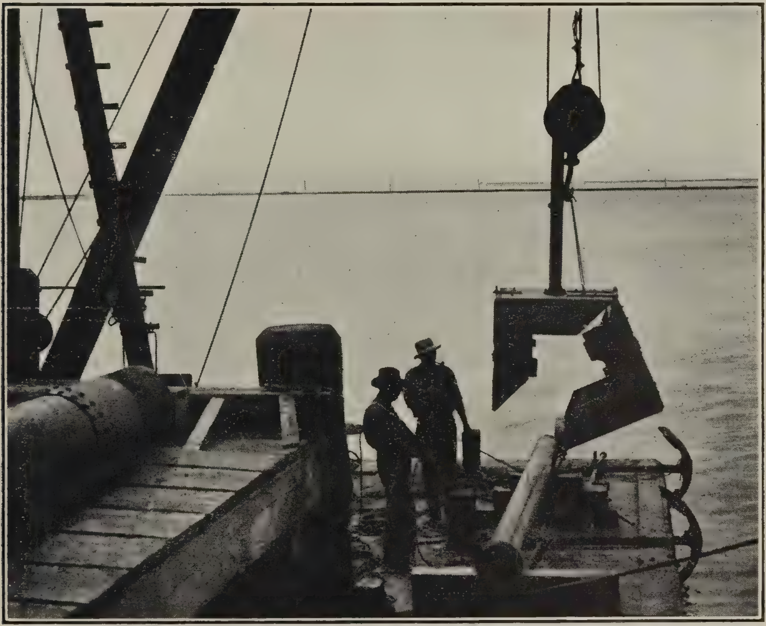


Fig. 4. Showing method of placing form.

On the last leaks which were closed, pouring the cement through the pipe was abandoned owing to too much lost time in waiting for it to settle. The pipe, however, was still used to lower the form and to hold the form in position until piling were driven. After this it was taken off and the cement, which was mixed as thick as possible, was lowered down to the diver in buckets and poured into the form through the hole at which the pipe had connected.

Where the soft mud and silt was so bad that it could not be kept out of the form, a 4-inch centrifugal pump with a flexible suction end was used to clean out the form after it was in place and all closed, the mud being pumped out through the cement filling hole while a jet alongside stirred it up. In the work of closing these leaks it was found necessary to have the pipe and inside of the form absolutely clean, so that the cement would adhere to the pipe. It was found necessary to take the form off the first leak and do the work all over again, as mud had been pocketed in the grout.

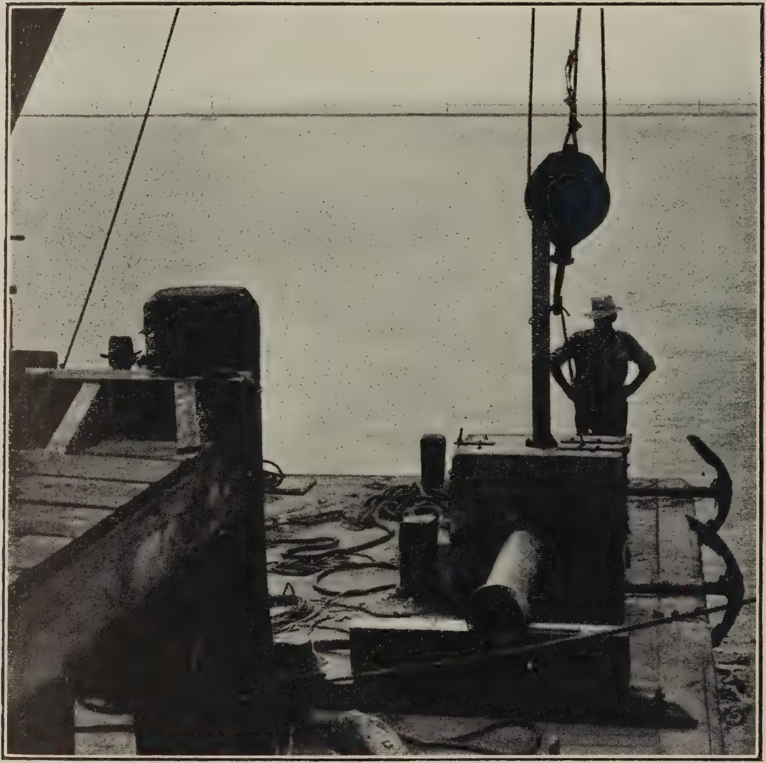


Fig. 5. Form placed.

When repairs were completed, all cement was allowed to set a week. About 40 pounds of air pressure was then put on the main and kept on for over an hour. During this time not a single air bubble could be seen and the water meter showed the leaks had been stopped.

Four leaks were repaired and the entire work was executed in about four weeks, including the time of assembling plant, dredging, building forms, etc. By actual time a form was lowered and fastened around the pipe in forty-five minutes. To close the false end gates of the form required fifty minutes. To drive the piles required from one to one and a half hours, depending on how hard the driving was. To mix the cement and fill the form required one hour and fifteen minutes. A good deal of credit is due the diver for the rapidity with which the form was placed. In this connection it is interesting to note that during the entire work the diver went down without a suit, simply placing the diving helmet over his head.

With the proper plant after the main is clear, one leak a day can be repaired. The total cost of the repair work, closing four leaks, was $2,300.00.

The work was done by the United States Engineer Department, under the direction of Lieut. Col. C. S. Riché, Corps of Engineers. The plan of closing the leaks was devised, the form was designed, and work superintended by Mr. O. R. Scott, U. S. Inspector. The force consisted of 1 foreman, 1 hoisting engineer, 6 laborers and 1 diver, Mr. Albert Majors of Galveston.

The Teredo in Fresh Water

BY

MR. R. G. MCGLONE
Junior Mechanical Engineer

As it seems to be the popular belief that the common teredo, or ship worm, can exist only in sea and tide waters and that its transfer to fresh water would result in its death, it is believed that the following experience to the contrary will be of interest.

The U. S. snagboat *Waco* was built at Jeffersonville, Ind., the hull being constructed of long leaf yellow pine, except rake planking, which before launching was painted with carbolineum. All rake planks were of oak.

As soon as the vessel was completed she started on the trip from Jeffersonville to the Brazos River, spending, altogether, two and one-half months in tide water, including the time spent in snagging the Brazos below Mile 40. The effect of the tide is perceptible up to this point, although there is no sign of barnacle or teredo life above Mile 20.

After passing Mile 40 the *Waco* spent the next two years and ten months working her way upstream to Mile 171, from which point she was recalled and hauled out for repairs. An examination of the hull planking was made and found to be fairly well honeycombed by the teredo, necessitating the renewal of all bottom planking and the greater portion of the gunwales. Samples of the rakes were taken and photographed, as shown by the accompanying illustrations.

Some of the specimens of the teredo that were examined were three quarters of an inch in diameter and eighteen inches long, all alive and healthy at the time planks were removed.

The following analysis of Brazos River water, taken at Mile 418 shows a high percentage of salt, an amount 18.7 times that contained in samples taken from the Guadalupe River:

	Parts per million.
Iron and alumina	11.00
Silica	162.10
Calcium carbonate	460.50
Magnesium sulphate	120.00
Sodium sulphate	463.60
Sodium chloride	770.48
Alkalinity equals Sodium hydroxide	14.00

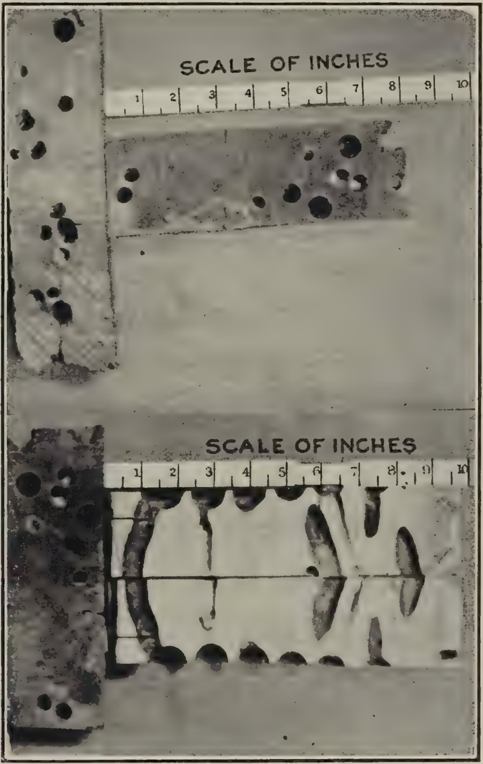


Fig. 1. The upright piece on the left taken from the *Waco* is sawed parallel to the grain, while the one on the right is parallel thereto. Both show the teredo holes.

It is possible that the gradual transfer of the *Waco* from salt water to fresh, together with the natural saltiness of the river, has been a factor in preserving the life of many of the teredoes that had gotten into her planks.

There is no doubt that the specimens were genuine teredos, as they showed all the characteristic features, and the holes left by them were lined with calcareous matter.

INDEX

With this number of the **Professional Memoirs** appears, as Supplement No. 2, *a complete index of the first five volumes of the* **Memoirs**. ¶One of the primary objects of the **Memoirs** is to provide a reference library on Military, River and Harbor and other engineering pertaining to the Engineer Department. It is thought this index will further this object by making the information more available

PROFESSIONAL MEMOIRS

Corps of Engineers, United States Army, and Engineer Department at Large

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Maj. FREDERICK W. ALTSTAETTER, *Editor.* Lieut. EARL J. ATKISSON, ***Business Manager.***

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Contents

(*Illustrations in each article are shown by italics.*)

Page.
1. WORKS AT THE FALLS OF THE OHIO RIVER, LOUISVILLE, KY.. 563-603
By Maj. J. C. Oakes, Corps of Engineers; M. Am. Soc. C. E.
Louisville Locks 569
Head of Locks; showing Upper Gates, Bridge over Lock, and Guard Gate 571
Steamer with Tow of Empty Coal Boats 579
Widening Canal; Looking East toward Head of Canal 581
Widening Canal; Looking West from Basin at Head of Canal 583
Lock Pit Excavation; Looking West, Present Locks on Right 589
Lock Pit Excavation; Middle Gates show between Operating Houses 591
2. DEVELOPMENT OF EXPLOSIVE FOR OUR DEMOLITION EQUIPMENT 604-614
By Maj. W. G. Caples, Corps of Engineers.
Trinitrotoluol blocks and pasteboard containers, copper wire, crimper, etc. 607
Cap Boxes; Open, closed, and filled 609
Detonating cord 613
3. FIELD FORTIFICATIONS BASED ON PRACTICAL EXPERIENCES OF THE RUSSIAN-JAPANESE WAR 615-630
Reprinted, by permission, from the January, 1914, number of the *Journal of the United States Cavalry Association.*
Kneeling skirmisher's trench 620, 623
Prone skirmisher's trench 622
Drainage ditch and drainage pit 624
Drainage ditch extending to the front 625
Intrenchments made with long-handled tools only 625
Intrenchments made with long and short handled tools 626
Manner of intrenching a division with long and short-handled tools 627
Bombproofs 630
4. THE U. S. SEAGOING SUCTION DREDGE "NEW ORLEANS" 631-643
By Maj. Edward H. Schulz, Corps of Engineers.
The U. S. Seagoing Suction Dredge "New Orleans" 633, 637
Methods of attaching cable 642
5. NOTES UPON THE WATER HYACINTH 644-648
By Capt. R. T. Ward, Corps of Engineers.
Water Hyacinth 644
6. WILLIAM FARRAR SMITH 649-650
By Lieut. Joseph C. Mehaffey, Corps of Engineers.
7. WINTER WORK IN THE CONSTRUCTION AND REPAIR OF DAMS AND SHORE PROTECTIONS IN THE UNITED STATES IMPROVEMENT OF THE UPPER MISSISSIPPI RIVER 651-660
By Mr. C. W. Durham, Principal Assistant Engineer.
Winter repairs; hauling rock and willow fascines on sled 655
Building a dam on the ice; willow fascines built into a mat 657
Winter repairs 658
8. BOOK REVIEW 661-662
9. ERRATUM 662
10. SELECTED ARTICLES OF ENGINEERING INTEREST .... vii -xix
By Mr. Henry E. Haferkorn, Librarian, Engineer School.

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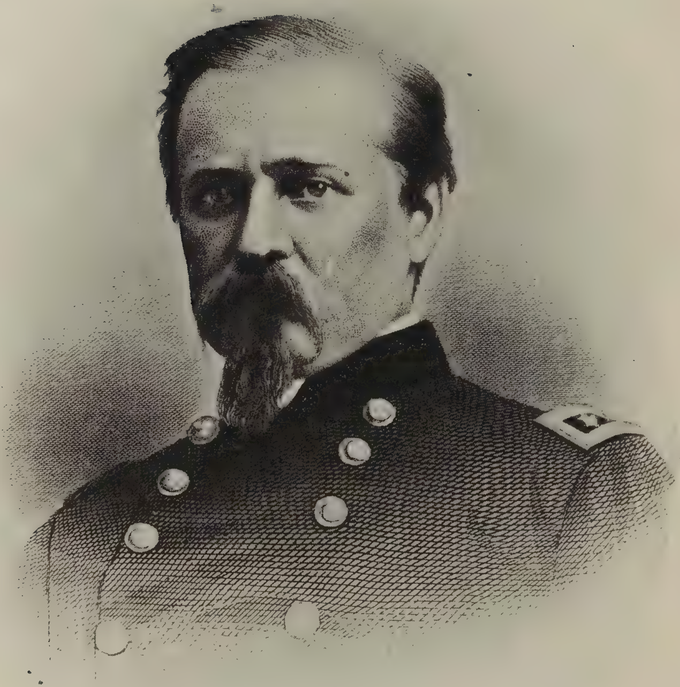

MAJ. GEN. WILLIAM FARRAR SMITH
1824-1903
CORPS OF ENGINEERS
U. S. ARMY

SEE PAGE 649

Works at the Falls of the Ohio River, Louisville, Ky.

BY

Maj. J. C. OAKES
Corps of Engineers; Member American Society of Civil Engineers

The obstruction to navigation of the Ohio River known as the "Falls of the Ohio" lies opposite Louisville, Ky., and is formed by an irregular mass of limestone underlying the entire width of the river. The head of the falls is approximately 602 miles by river from Pittsburgh, Pa., and 364 miles from Cairo, Ill. This mass of rock forms a natural dam, creating a deep pool above and a fall at low water stages of 27 feet from head to foot of falls. (Fig. 1.)

The discharge at this point varies from about 4,000 c. f. s. at low water, with lower gage reading 2 feet, to about 790,000 c. f. s. at extreme high water with gage reading 72 feet. The gage readings above the dam vary from 1.7 feet to 46.7 feet.

The river at the head of the falls is about 1 mile wide, while below Louisville for some 50 miles its width is approximately one-half as great. During floods the contraction of the river below causes the lower pool to rise more than twice as fast as the upper pool, until at a 16-foot stage upper pool there is generally a fall between head and foot of falls of about 2 feet. Navigation of the open river becomes possible for steamers of the usual type when the fall does not exceed 7 feet for downstream navigation and about 5 feet for upstream navigation. In their natural condition the falls were impassable during the greater part of the year, and at all times navigation is difficult and dangerous, not only because of rapid current but because of the piers of two railroad bridges crossing the river and also a very sharp bend in the channel at the foot of the falls.

There are three channels or chutes over the falls known as the Indiana, Middle, and Kentucky chutes, the former being the principal channel and the one most navigated. It is located near the Indiana shore, north of Goose Island, and makes a sharp bend, called the Big Eddy, near the foot of the falls. This channel is 4,659 yards, or about 2 2-3 miles, long. At extreme low stages one-half of its total fall, or 13 feet, occurred before improvement in the first 1,253 yards, and about two-thirds of the fall, or 17½ feet, occurred in the first 1,986 yards. The Middle Chute begins about the middle of the river and passes down between Goose and Rock islands. Its length is about 3,800 yards, and about 22 feet or almost the entire fall is in the last 500 yards. The Kentucky Chute lies near the Kentucky shore south of Rock Island. It is similar to the Middle Chute. Almost the entire fall is in the last 200 yards. As the river rises the Indiana Chute first becomes navigable, then the Middle Chute, and last the Kentucky Chute.

Before the canal and locks were constructed, passage of boats was impossible for about ten months each year and all freight had to be unloaded, hauled around the falls and reloaded.

HISTORY OF THE IMPROVEMENT.*

Agitation for the construction of a canal with locks is known to have taken place as far back as 1793, and shortly after 1800 various plans were suggested and attempts made to carry them out by individuals, associations, and incorporated companies. Under a charter granted in 1825 by the legislature of Kentucky a stock company was formed, the United States being a share holder, and actual construction work was begun. A canal with three locks was constructed, the first boat passing through the canal December 22, 1830. As originally constructed, the canal was 1.9 miles long and 64 feet wide; three locks in series were located at the foot of the canal, with chambers 198 feet between miters, available length about 170 feet, width 50 feet, and each had a lift of about 8 feet 5¼ inches. The cost, including purchase of land, was $1,019,277.09. Tolls were collected from 1831-1842, inclusive, amounting to $1,120,350.55.

Very soon after the opening of the canal there were many complaints. It was urged that the collection of tolls was a monopoly granted to private individuals; that the canal was in fact a part of the great National highway, the Ohio River, that the tolls levied a heavy tax on commerce and ought not to be imposed for the benefit of individuals; and that the work should be turned over to the United States for control and improvement. The charter

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*Extracted from the report of General Weitzel, Corps of Engineers, dated February 10, 1882.

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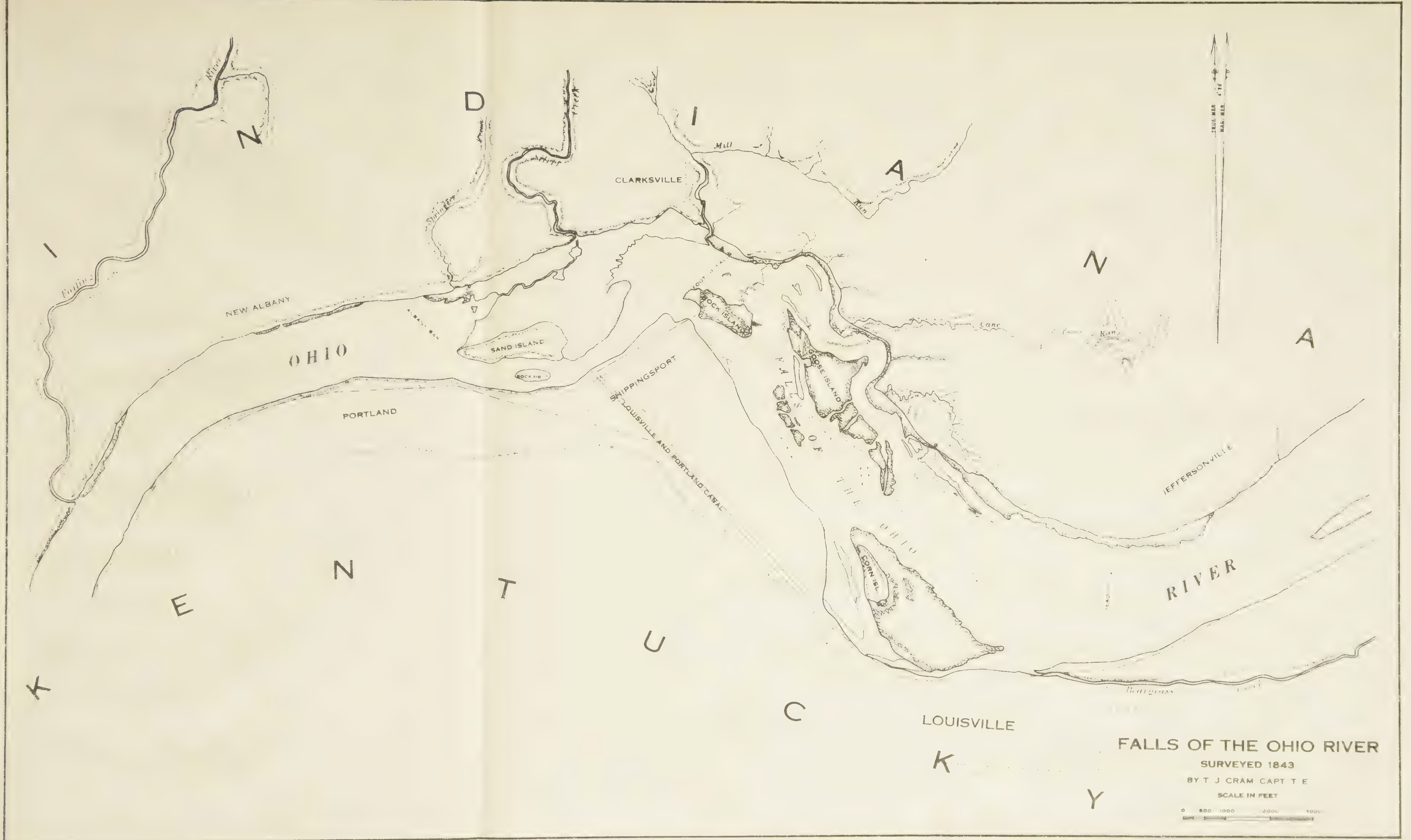
FALLS OF THE OHIO RIVER

SURVEYED 1843

BY T J CRAM CAPT T E

SCALE IN FEET
0
500
1000
2000
3000
INDIANA
KENTUCKY
OHIO
RIVER
NEW ALBANY
CLARKSVILLE
Mill Run
Cane Run
Silver Creek
Falling Run
Falling
Spring
SAND ISLAND
ROCK ISLAND
ROCK ISLAND
GOOSE ISLAND
CORN ISL
SHIPPINGSPORT
LOUISVILLE AND PORTLAND CANAL
PORTLAND
FALLS OF THE OHIO
JEFFERSONVILLE
LOUISVILLE
Beargrass
TRUE MER
MAG MER
4°2d

FIGURE 1. BEFORE IMPROVEMENT.

was therefore changed January 21, 1842, authorizing the board of directors to use the income from tolls to purchase stock of private individuals with a view to turning the stock over to the United States on condition that the Government would levy only sufficient tolls to pay expenses. Between 1842 and 1854, 7,093 shares were purchased for $1,419,062, and the shares turned over to the United States. At this time the stock was held as follows: by directors, 5 shares; by directors in trust for United States, 7,093 shares; by United States, 2,902 shares; total, 10,000 shares.

As Congress failed to take over the property the charter was again amended December 19, 1857, authorizing the construction of a branch and the enlargement of the old canal. Money was raised by issuing bonds, land was purchased, detailed plans were made by Mr. Theodore R. Scowden, a distinguished engineer, and the work of enlargement was begun. The civil war so increased the cost of material and labor that in 1866, after expending $1,825,403, the directors were obliged to suspend work. At this time the following was the condition of the work (Fig. 2): the masonry work of the new locks was completed except the sills; upper guard gates completed; two bridges were built; the timber for the gates was on hand and partly framed; the machinery for moving the gates was partly finished but not delivered; the rock ledge below the locks had been removed; the lock chambers and channel from lock to river were filled with sediment, and trees 3 inches in diameter were growing in the locks; a large portion of excavation in branch canal and basin and a small part of the excavation for widening the canal was completed.

Appeal was made to the Federal Government for assistance and by act of July 25, 1868, Congress appropriated for completing the works and made provision for taking over the canal, locks, etc., on condition that all title and right in the canal should be ceded and vested in the United States.

The work was completed practically as designed by Mr. Scowden and provided: a depth of 6 feet in the canal by means of excavation and a guiding dike and cross dam at the head of the canal (to be described later); a width of canal 86½ feet between vertical walls 15 to 17 feet high; two locks in series, each 372 feet between quoins or 348 feet available length by 80 feet width with 13½ feet lift. The new work was completed and on February 26, 1872, the locks were opened to commerce. The canal continued in charge of directors until June 10, 1874, when the works were transferred to the Federal Government represented by General Weitzel, Corps of Engineers, U. S. Army, who had been in charge of the completion of the work appropriated for by Congress in 1868.

The passage of the falls was now practically possible at all stages, the locks being used up to the 12.7 foot stage (upper pool)† after which the open river could be navigated. Tolls were greatly reduced and finally abandoned altogether July 1, 1880.

Costs.

Old canal, private company	$1,019,277.00
Improvements, private company	*120,000.00
Enlargement, private company	1,825,403.00
Enlargement, Government funds	*1,463,300.00
Enlargement, canal tolls expended	*150,000.00
Total cost	*$4,577,980.00
Cost to the Government, original stock purchase	$233,500.00
Cost to the Government, enlargement	1,463,300.00
Canal enlargement bonds assumed	1,172,000.00
	$2,868,800.00
Deduct cash dividends received	257,778.00
Total cost to the Government	$2,611,022.00

The canal and new locks as designed and constructed have remained in use up to the present time with practically no changes. The depth in the canal has been increased, however, from 6 to 9 feet by the construction of the present dam extending from the canal wall at the head of the canal to the Indiana shore. The works therefore still continue to serve navigation for the deepest draft vessels used on the river, which are the coal boats drawing, when loaded, about 8 feet.

The length of the canal, including locks and lower entrance, is 2 1-7 miles; the widths are, Louisville Harbor, 800 feet; upper entrance of canal, 400 feet, reducing to 200 feet; throughout the canal, 86½ feet; and at the basin above the locks 215 feet. The depth of water in the canal varies with the stage of the river, being 9 feet minimum when the dam is raised, but in the winter when the dam has to be down on account of ice the minimum depth is that of the natural stage of the river, which may be as low as 2 feet. During such times, however, navigation is closed on account of ice. The highest water recorded was that of the flood of 1884, 46.7 feet

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*About.

†The zero of the upper gage is at elevation 403.004 Sandy Hook datum, which is also the level of the bottom of the canal at its upper entrance.

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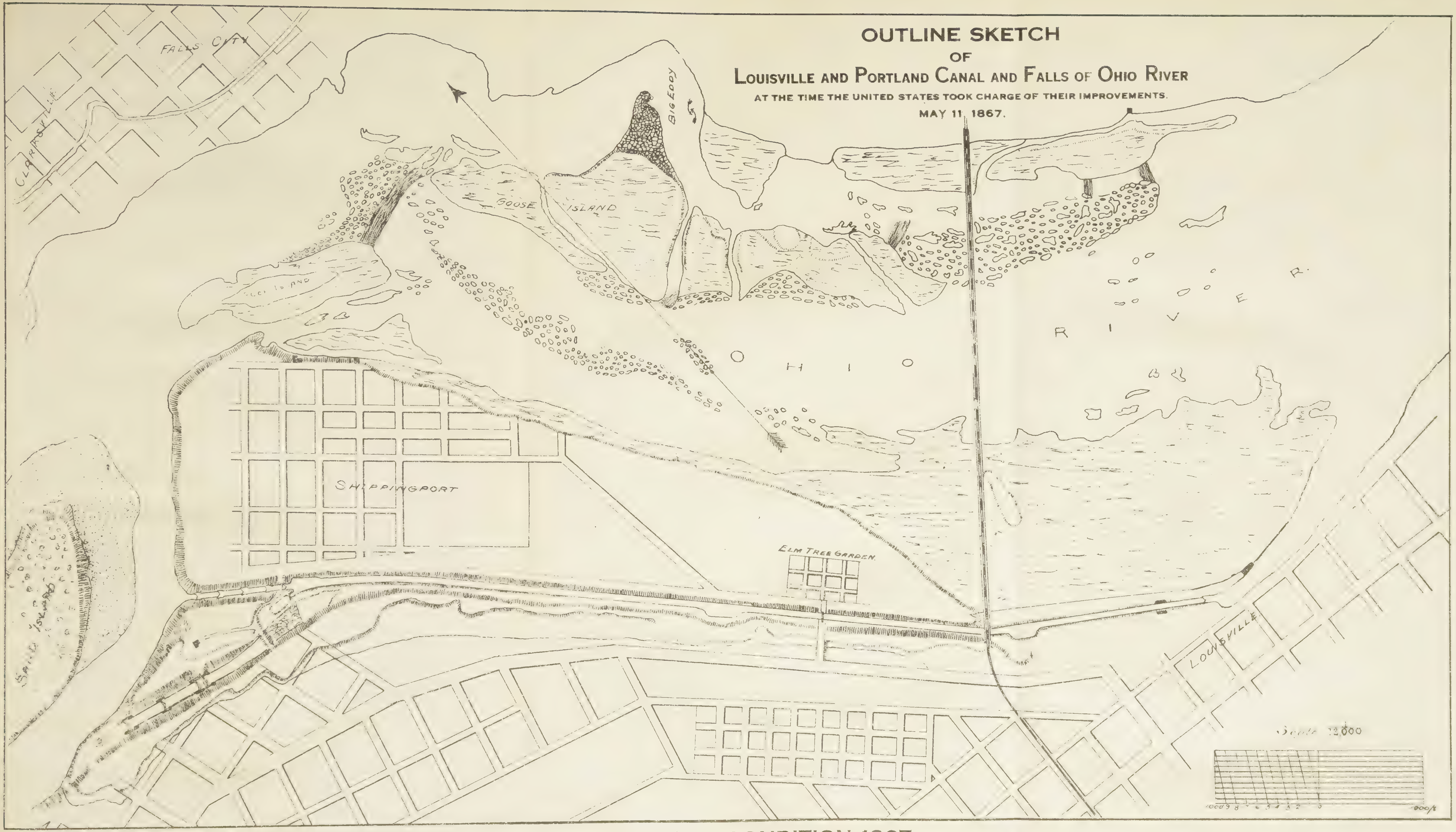


OUTLINE SKETCH
OF
LOUISVILLE AND PORTLAND CANAL AND FALLS OF OHIO RIVER
AT THE TIME THE UNITED STATES TOOK CHARGE OF THEIR IMPROVEMENTS.
MAY 11, 1867.

FALLS CITY
CLARKSVILLE
GOOSE ISLAND
BIG EDDY
CORN ISLAND
OHIO RIVER
SHIPPINGPORT
ELM TREE GARDEN
SAND ISLAND
LOUISVILLE
Scale 1/12,000
1000 9 8 7 6 5 4 3 2 0
1000 ft

FIGURE 2. CONDITION 1867.

upper gage when there was a difference of level of 1.6 feet between head and foot of falls. The bottom of the canal slopes about 3 feet from upper entrance of the canal to the locks. Masonry walls 15 to 17 feet high with vertical faces toward the canal protect the banks. From the top of these walls, after leaving a berm 15 to 30 feet wide, earthen embankments with slopes of 2 on 1 rise to a height of 50 feet above the canal bottom, which height is above that of highest water. The embankment on the north separates the canal from the river proper, so there is no flow from the canal to the river even at the highest river stages except through the locks.

DATUM PLANE FOR SURVEYS AND WORKING DRAWINGS.

Before considering the subject further it becomes necessary for a proper understanding of the following descriptions and drawings to explain the references to elevations and gages.

The datum plane to which all Government works on the Ohio River are referred is that of the U. S. Geological Survey, viz, mean tide at Sandy Hook, N. J.

Two gages are maintained at Louisville, one below and one above the locks, the lower having its zero at elevation 376.056 and the upper having its zero at elevation 403.004, or as used in this article 376 and 403, respectively.

PRESENT LOCKS.

These locks, two in series, are 372 feet long between quoins with available length of 348 feet, are 80 feet wide and have wooden mitering gates.

The lower miter sill is at elevation 374, middle sill at elevation 384, and upper sill at elevation 401. Low water below locks, elevation 378; above locks, 404.7 with dam down, and with dam up elevation 412, making a maximum lift of 34 feet to be divided between the two locks. Of this lift the upper lock takes about 15 feet and the lower lock the remainder. On a rising river, by gradually lowering the dam the pool is held at about elevation 412 until all of the dam is down, when the natural stage results. At such time the lower pool has risen to elevation 395 (approximately), and the lower lock is then drowned out and only the upper lock is used. This lock may be used until the stage (upper pool) is about 4 feet above normal pool level, when the middle gates are drowned out and navigation of the canal ceases. By such time the fall of the river has been reduced to about 2½ feet and the open river can be used, although the passage of the falls is always dangerous.

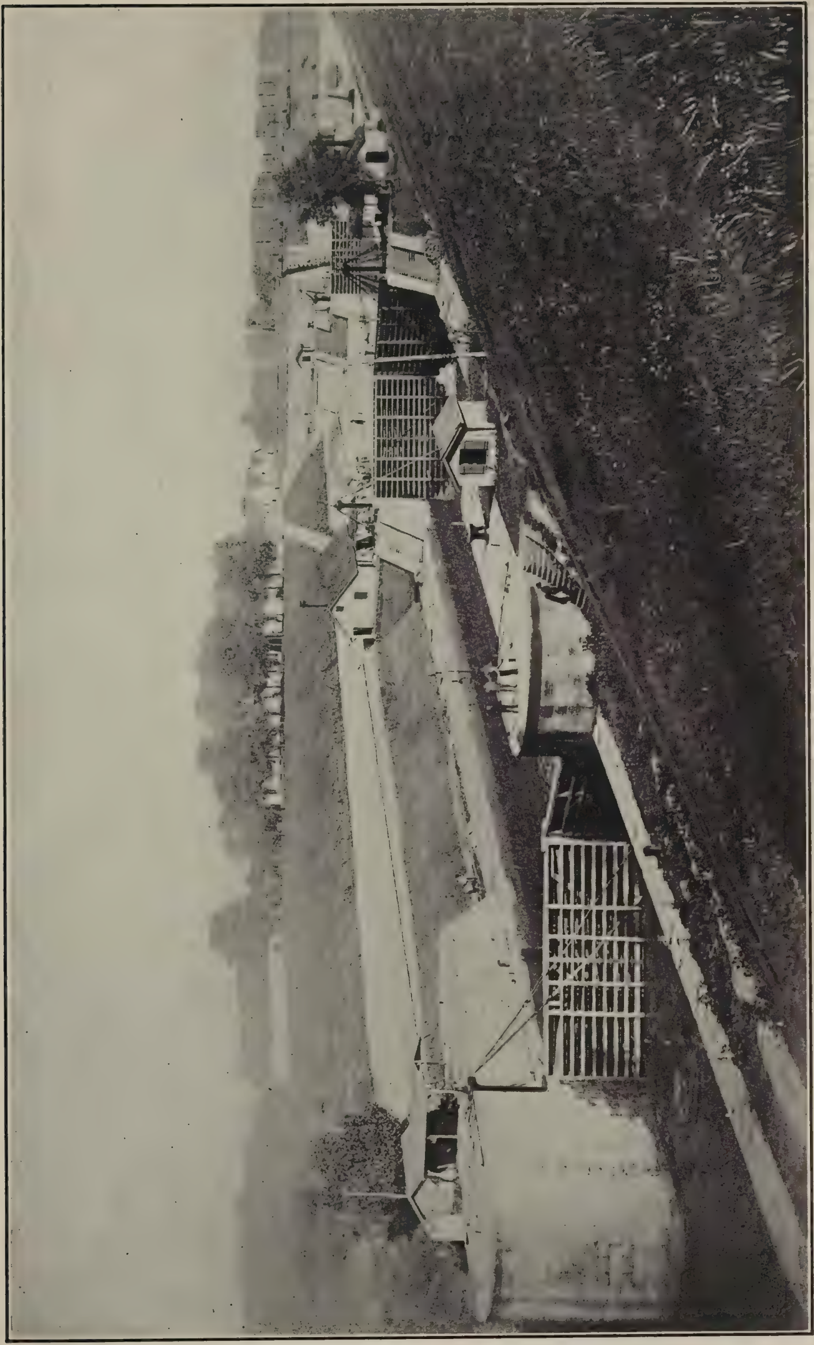
The gates are of the mitering type, built up of timber and operated by chains attached to the bottoms and passing under pulleys up through the walls to capstans. At times the operating chains are broken and require the operations of a diver to make repairs. Six capstans for the three sets of operating gates are operated by two steam generating plants, one on each wall opposite the middle gates. Steam is led to the capstans at the other gates in pipes extending along the walls. The guard gates are operated by hand. During floods all of these capstans and steam plants are covered by flood water, resulting in deposit of silt which must be cleaned from the walls and machinery after each flood.

Each gate has a cast iron socket on foot of the quoin post, which turns on a pivot bolted to the rock. The top of the quoin post is held in an iron collar anchored into the walls. To relieve a portion of the weight on this collar and to prevent sagging, a roller is placed under the gate near the miter post and iron rods lead from the top of the gate at intervals to an iron mast projecting some 10 feet above the walls.

The lock chambers are filled and emptied through the gates—ten openings 30 inches by 36 inches in each set of gates. These openings are controlled by butterfly valves turning about vertical axes and are operated by hand from the top of the gates. The time of lockage varies with the stage of water and the type of boat passing through. Packets pass through both locks in about thirty minutes, but coal boats and barges require from forty-five minutes to about an hour.

During each flood stage silt is deposited in the canal and locks. The removal of this deposit requires the practically continuous operation of two small dredges, one clam shell and one dipper, with towboat and scows. The dam requires two maneuver boats to be constantly available, although their use is intermittent.

The top of the upper gates of the upper lock is at elevation 422.5. The water surface of the canal having the same elevation as the upper pool varies with the stage of the river, and in 1884 reached elevation 449.7. To prevent a swift current through the canal at high stages which might damage the locks, guard gates have been provided above the upper operating gates with their sill at the same elevation as that of the upper gates but with the top of the guard gates at elevation 444.9 above all stages, except the floods



Louisville Locks. New lock to be constructed on this side of present locks. (See page 567.)

of 1884 and 1913 when the fall between upper and lower pools was only about 9 inches and the current was harmless.

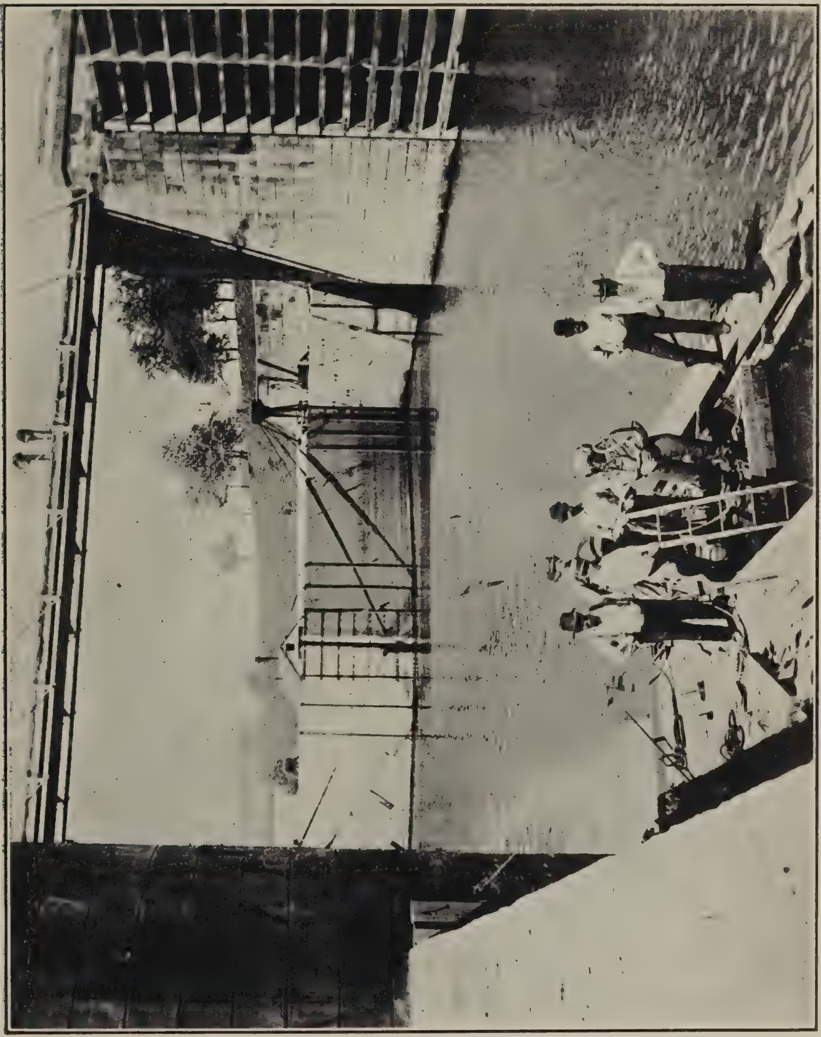
The first locks constructed (three small ones) soon fell into disuse and at a later date, about 1896, it was proposed to place in the upper of these locks a bear-trap dam for use in flushing out the canal sediment which is deposited during each high water. This bear trap was constructed and was in successful operation for several years, but the construction of the new dam increasing the depth in the canal from 6 feet to 9 feet put it out of commission. These locks are at present not in use and are to a great extent filled with sediment. Guard gates are maintained at their head to prevent flow through them from the canal to the river below. Under a contract recently entered into for the widening of the canal to 200 feet between walls, provision is made for filling these locks and raising the elevation of the land adjacent to provide additional land for the construction of offices, power plant and shops.

For the purpose of providing means for rapid repair of operating machinery, gates, towboats, dredges, scows, dam trestles, wickets, etc., rather elaborate shops have been constructed adjacent to the locks. These shops include saw mill and planer, carpenters and blacksmiths shops, with compressor plant for operating hand tools, machinery for forging and turning iron in the simpler forms, etc. A dry dock, 80 by 250 feet, is operated just above the locks on the north side of the canal. There are also provided an office, superintendent's house, stable, etc. The annual cost of operating the lock and dam with repairs, etc., has averaged $97,218.90 during the last ten years.

IMPROVEMENTS TO NAVIGATION OVER THE FALLS.

As early as 1875 work was performed to improve open river navigation, and until the completion of the present dam in 1910 almost each year saw some work projected or performed. The project provided at first for the removal of rock bars or reefs which obstructed the chutes, but was modified to include the construction of dikes. During successive years as river conditions would allow, the worst of the rock bars were drilled, blasted, and the loose rock removed and dikes were constructed on Goose Island, at Willow Point on the Indiana bank and from the Indiana bank across Sand Island.

The route over the falls is being used less and less each year.



Head of Locks: Showing Upper Gates, Bridge over Lock, and on right Guard Gate in its recess. (See page 568.)

No boat ever attempts the passage when the canal is open, and at stages when the canal can not be used, navigation is now as safe as it can be made except by extraordinary measures whose cost would be prohibitive. As a result of the proposed improvement of the canal and locks now being carried out further improvement of the chutes has been abandoned.

DAM AT HEAD OF FALLS.

An inspection of Fig. 2 will show that the original plan did not include a harbor at the head of the canal and no dike was provided to prevent vessels from being drawn over the falls when attempting to enter the canal. To provide the harbor and overcome this danger a guiding dike, connected with the north canal wall, was constructed from the head of the canal along the crest of the falls in front of the Louisville landing. It was soon apparent that sufficient depth had not been provided in the canal and to increase such depth, and also to concentrate the flow through the Indiana Chute, a cross dam was constructed from a point near the outer end of the dike along the crest of the falls to the Indiana Chute.

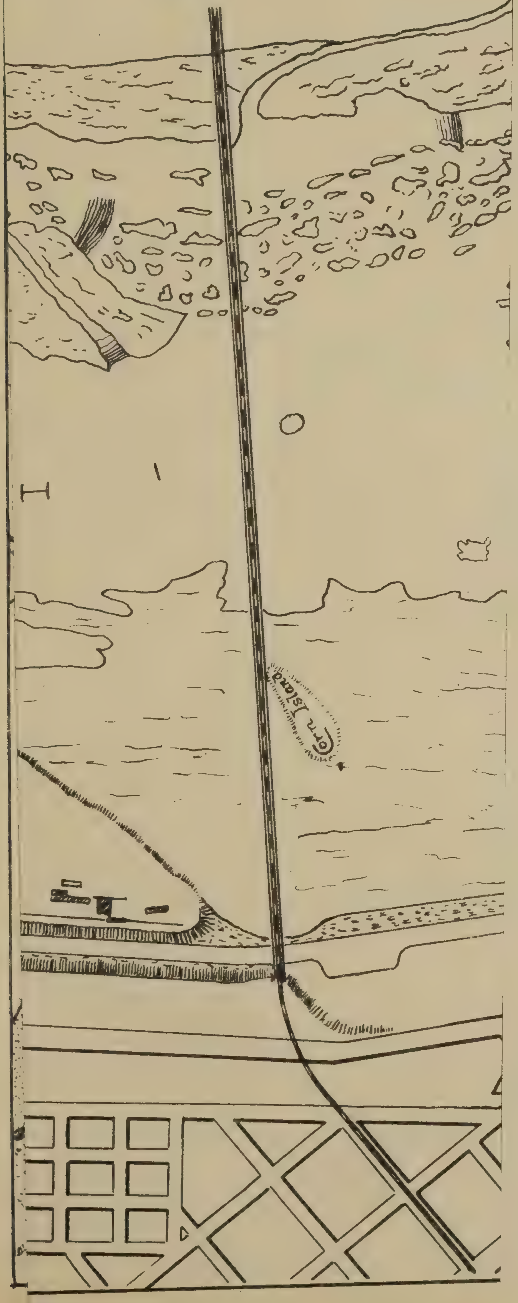
As early as 1868, Gen. G. Weitzel, Corps of Engineers, recommended such dike and cross dam to raise the low water depth in the canal to 6 feet and by 1878 the dike and dam had been constructed as shown on Fig. 3. The pass leading to the Indiana Chute was left open, but as early as 1875 General Weitzel proposed to close this pass by a movable dam and also to cut a pass in the permanent cross dam at the head of the Middle Chute and close the interval by a movable section. The dike and cross dam were constructed of timber cribs.

As soon as the guiding dike was completed, measures were taken to excavate the rock between it and the Kentucky shore to provide additional depth and width for the Louisville Harbor.

From 1878 up to the completion of the present dam in 1910, the dike and cross dam were changed and improved to provide additional facilities as they were needed by the growth of river traffic.

By 1899 it had become apparent that the depth in the canal must be increased to 9 feet and that the easiest and cheapest manner of doing so would be by the construction of a new dam extending from the canal wall to the Indiana bank with movable sections for regulation. As a result of numerous studies there was finally adopted and constructed the present dam, which is entitled to a detailed description.

OUTLINE SKETCH
OF
PORTLAND CANAL AND FALLS OF OHIO
AT CLOSE OF FISCAL YEAR.
1878.


Corn Island

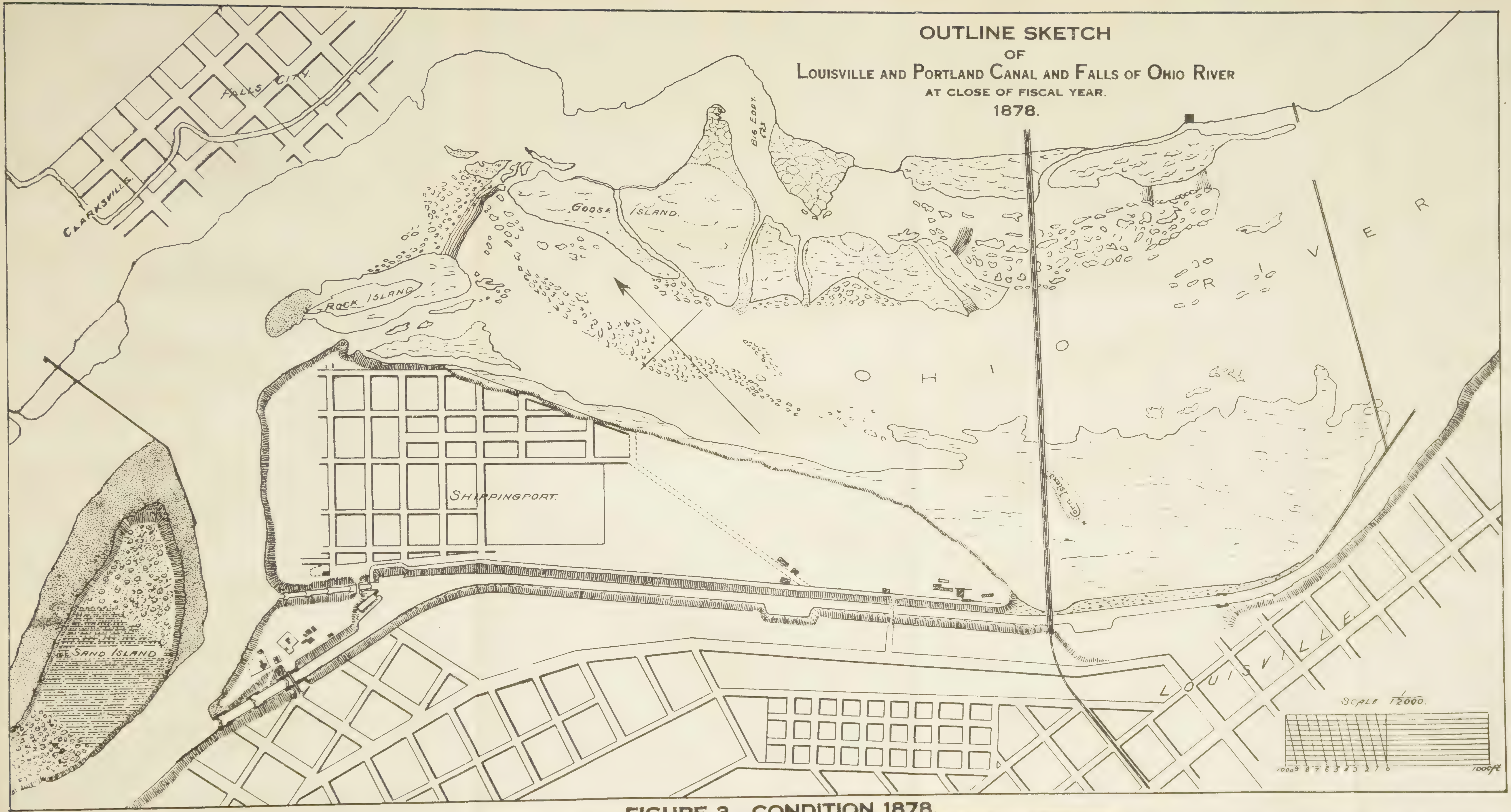

OUTLINE SKETCH
OF
LOUISVILLE AND PORTLAND CANAL AND FALLS OF OHIO RIVER
AT CLOSE OF FISCAL YEAR.
1878.
FALLS CITY.
CLARKSVILLE.
GOOSE ISLAND.
BIG EDDY.
ROCK ISLAND
SHIPPINGPORT.
SAND ISLAND
Corn Island
OHIO RIVER
LOUISVILLE
SCALE 1/12000.
1000 9 8 7 6 5 4 3 2 1 0
1000 ft

FIGURE 3. CONDITION 1878.

PRESENT DAM.

(Fig. 4.) The irregular shape of the crest line of the dam is the result of its growth. There was first constructed the guiding dike, extending from the head of the canal approximately parallel to the shore following the rock ledge. (See Fig. 3.) This was built to provide easier access to the canal by cutting off the flow of water over this portion of the rock ledge and to protect the Louisville landing. Before the dike was constructed many vessels failed to successfully enter the canal and were drawn over the falls. At about the same time it became necessary to build the cross dam to back up the water to obtain greater depth in the harbor and canal and to throw as much as possible of the water passing through or over the dam into the Indiana Chute to improve its navigability. It was natural, therefore, that the cross dam should be extended from a point near the end of the dike, as the distance to the Indiana shore was shortest along that line and a good rock foundation existed, making the expense of the cross dam a minimum.

The next improvement was to provide a wider harbor for Louisville at the head of the canal. The Louisville Cement Co. owned the land a short distance from the north canal wall, so in planning this improvement the canal wall and dam were placed along the south and east line of that company's property and thence to the cross dam approximately parallel to the guiding dike, thus leaving the old canal wall, dike, and a portion of the cross dam behind which the new walls could be built and the rock excavated for deepening the harbor. When the present dam was planned the portion of the old dam parallel to the guiding dike was retained, thus practically determining the location of the remainder of the dam.

The old cross dam raised the low water pool about 3 feet and the present dam raised it another 3 feet, giving at all times when the dam is in operation a depth of 9 feet in the harbor and canal and provides that depth upstream for 50 miles to Madison, Ind.

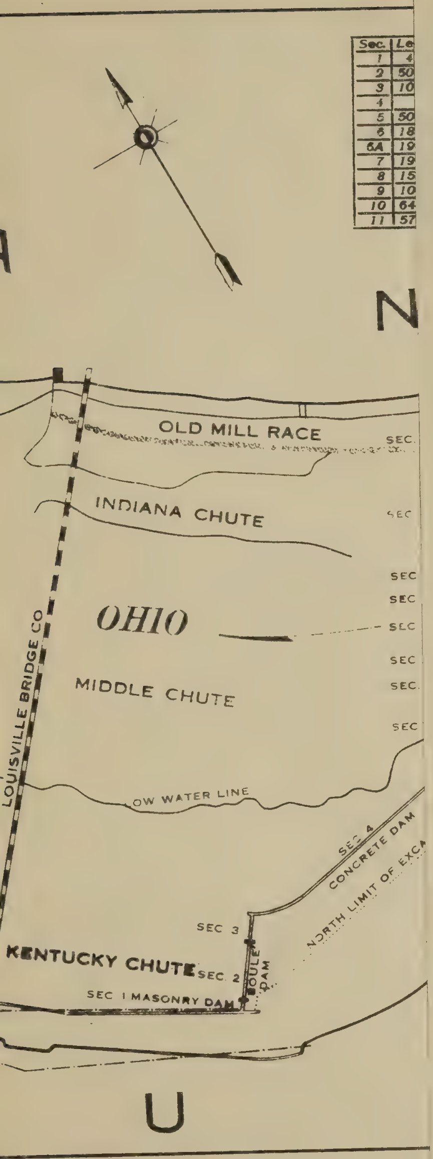
This dam had to be of a type that would provide a pool at low water stages but that would not materially raise the water level during floods nor increase the difficulties of navigation after the locks are drowned out. Some type of movable dam was necessary and it had to be so designed that it could be operated under the peculiar conditions existing at the site. These conditions may be mentioned briefly as follows: great width of river to be dammed; great fluctuations of water depths ranging from 2 to 46½ feet with discharge ranging from about 4,000 to 790,000 c. f. s.; steep slope below dam so that all water passing while dam is up runs away and there is practically no back water; difficulties due to ice and drift; difficulties of operation due to swift current; navigation of Indiana Chute to be provided for stages above 12.7 feet or 415.7 (upper gage).

The dam as built consists of eleven sections of Boulé gates, Chanoine wickets and permanent masonry weirs separated by piers as follows:

Dam No. 41 at Louisville.

Section.	Pier.	Length of section.	Width of pier.	Type.	Elevation.	
					Crest.	Sill.
Canal wall	----	-------	-------	Masonry	420.000	
1	----	48′ 7″	-------	Masonry	416.704	
----------	1	-------	12′ 0″	Masonry	416.704	
2	----	508′ 0″	-------	Boulé	415.904	406.404
----------	2	-------	16′ 3″	Concrete	416.704	
3	----	100′ 0″	-------	Boulé	415.904	406.404
----------	3	-------	16′ 0″	Masonry and concrete	416.704	
4	----	1820′9″	-------	Concrete	410.954	
----------	4	-------	10′ 1″	Concrete	413.504	
5	----	508′ 0″	-------	Boulé	413.004	403.504
----------	5	-------	16′ 3″	Concrete	414.504	
6	----	192′ 0″	-------	Boulé	414.004	404.504
----------	6	-------	18′ 3″	Concrete	414.504	
6-A	----	196′ 0″	-------	Boulé	414.004	404.504
----------	6-A	-------	16′ 3″	Concrete	414.504	
7	----	196′ 0″	-------	Boulé	414.004	404.504
----------	7	-------	16′ 3″	Concrete	414.504	
8	----	152′ 0″	-------	Boulé	414.004	404.504
----------	8	-------	16′ 3″	Concrete	414.504	
9	----	100′ 0″	-------	Boulé	414.004	404.504
----------	9	-------	54′ 0″	Concrete	414.504	
10	----	648′ 5″	-------	Chanoine	412.004	402.004
----------	10	-------	10′ 0″	Concrete	412.996	
11	----	575′ 9″	-------	Concrete	411.996	
Total	----	5045′6″	201′ 7″	Total length of dam=5247′ 1″.		

The movable sections are operated from maneuver boats and the Boulé sections were made short and separated by masonry piers because it was believed that a complete section should be either up or down on account of danger from ice and drift to unprotected ends of these sections, and it is supposed it was thought they would be easier to operate. It was feared also that the trestles, being held


Sec.
Le
1
4
2
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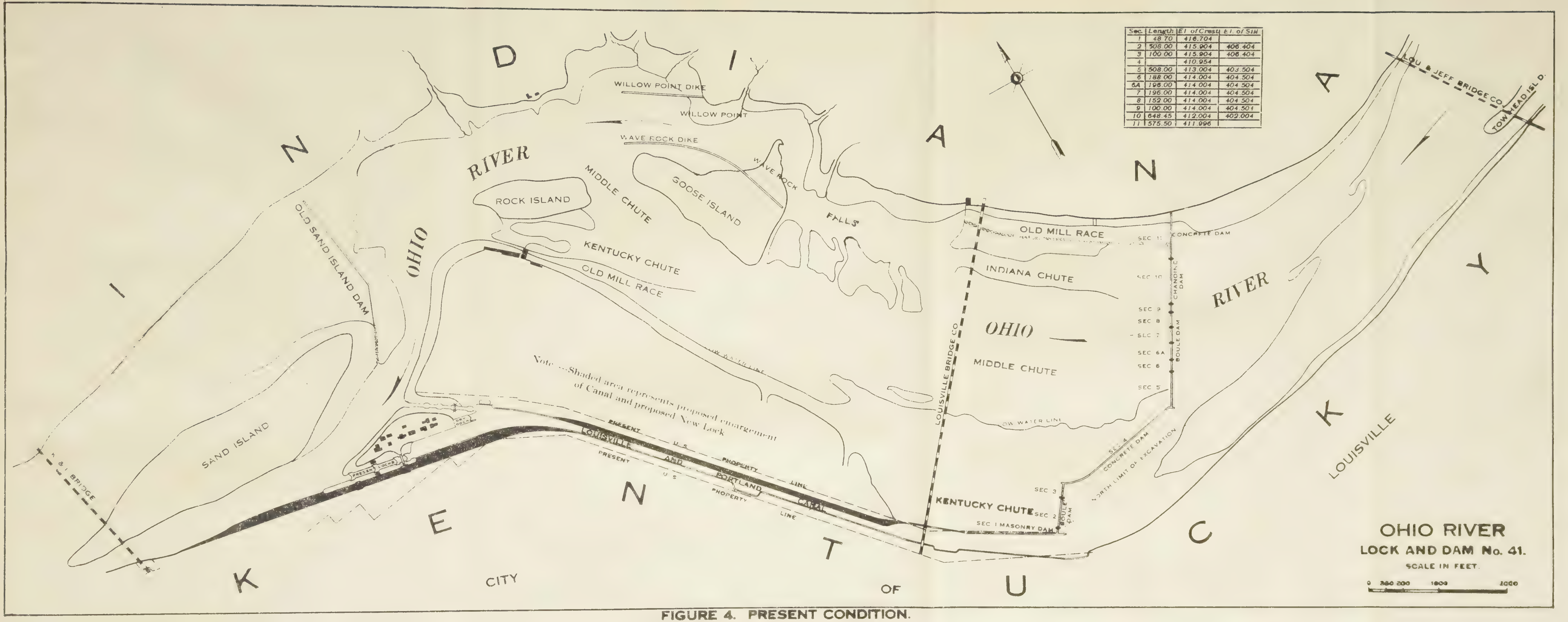
OLD MILL RACE
SEC.
INDIANA CHUTE
SEC
SEC
SEC
OHIO
SEC
SEC
MIDDLE CHUTE
SEC.
SEC
LOUISVILLE BRIDGE CO
OW WATER LINE
SEC. 4
CONCRETE DAM
NORTH LIMIT OF EXCA
SEC 3
KENTUCKY CHUTE
SEC. 2
BOULE DAM
SEC 1 MASONRY DAM
U



INDIANA
KENTUCKY
CITY OF LOUISVILLE
LOUISVILLE
OHIO RIVER
OHIO RIVER
OHIO
WILLOW POINT DIKE
WILLOW POINT
WAVE ROCK DIKE
WAVE ROCK
ROCK ISLAND
GOOSE ISLAND
MIDDLE CHUTE
KENTUCKY CHUTE
OLD MILL RACE
FALLS
OLD SAND ISLAND DAM
SAND ISLAND
K & I BRIDGE
PRESENT LOCKS
DRY DOCK
LOW WATER LINE
PRESENT U.S. PROPERTY LINE
PRESENT U.S. PROPERTY LINE
LOUISVILLE AND PORTLAND CANAL
LOUISVILLE BRIDGE CO.
OLD MILL RACE
INDIANA CHUTE
MIDDLE CHUTE
KENTUCKY CHUTE
LOW WATER LINE
SEC 11
SEC 10
SEC 9
SEC 8
SEC 7
SEC 6A
SEC 6
SEC 5
SEC 4
SEC 3
SEC 2
SEC 1 MASONRY DAM
CONCRETE DAM
CHANOINE DAM
BOULE DAM
BOULE DAM
SEC 4 CONCRETE DAM
NORTH LIMIT OF EXCAVATION
LOU & JEFF BRIDGE CO.
TOWHEAD ISL. D.
0 250 500 1000 2000

Sec.	Length	El of Crest	El. of Sill
1	48 70	416.704	
2	508.00	415.904	406.404
3	100 00	415.904	406.404
4		410.954	
5	508.00	413.004	403.504
6	188 00	414.004	404.504
6A	196.00	414 004	404 504
7	196.00	414.004	404.504
8	152 00	414.004	404 504
9	100.00	414.004	404.501
10	648.45	412.004	402.004
11	575.50	411.996	

Note.—Shaded area represents proposed enlargement of Canal and proposed New Lock

OHIO RIVER
LOCK AND DAM No. 41.
SCALE IN FEET.

FIGURE 4. PRESENT CONDITION.

in place by connections with a certain amount of play, would lean forward by successive increments until there would be difficulty in placing the gates whose shapes are rectangular and can only be properly placed when the trestles are vertical. The piers were made wide to withstand shocks and the weight of accumulated drift, and those piers near the center of the river have sharp noses to break up ice floes and prevent gorges.

No other movable dam of as great width or contending against such adverse conditions is known to exist anywhere. The work was therefore more or less experimental and in view of the knowledge available at that time is very successful. The dam accomplishes its many purposes and when the project for 9 feet navigable depth for the entire Ohio River was adopted no dam was proposed to replace the present one, its operation being sufficiently successful to warrant its retention in the general project as Ohio River Dam No. 41. Experience has, however, developed several defects in the dam as constructed and as a result of increasing knowledge of the action of this and other movable dams, notably on the Upper Ohio, Kanawha, Big Sandy, etc., it is thought many improvements could be made if the dam were to be rebuilt.

Between sections 1 and 2 and 2 and 3 there are rather wide piers with rounded noses and between sections 5, 6, 6a, 7, 8, and 9 there are wide piers with sharp noses extending some 42 feet upstream from the crest of the dam. In all movable dams with considerable head the greatest difficulty of operation is met in placing the last few wickets or gates. Therefore the greater the number of sections the greater the difficulty. In such dams, operated from a maneuver boat, flat-headed piers whose upstream surface is practically coincident with the crest of the dam should be provided for the boat to rest against in starting the work, and to enable the boat to slide from the pier to the dam without difficulty. Such is not the case with Dam No. 41. With its projecting piers creating increased velocities, it becomes very difficult to hold the maneuver boats in position until a sufficient length of each section is raised to provide support for the boat. Due to these defects in the present dam, the operating boats and barges, on several occasions, have gone over the falls, and it is often necessary to use the dipper dredge with her spuds set in the river bottom as an anchorage in placing the maneuver boats between the piers. Besides being difficult, the operation is also expensive.

During the rise in the river which took place during January, 1913, it was impossible to lower the whole of this dam, and about 500 feet of section 5 remained up during the flood.

As soon as freezing weather is expected the Boulé sections must be lowered and pool navigation abandoned for the winter. This is because at ordinary stages there is no back water against the dam and ice forms readily on the trestle floor, and the ice thickens due to the small leakage between the gates until the trestles can not be lowered. If, therefore, when this condition exists a rise should occur with floating ice or drift, there is danger of damage or loss.

The only section of the dam that is operated easily at present is the Chanoine pass. The wickets of this pass are 10 feet 9 13-16 inches long and are raised and lowered from a maneuver boat at any stage of the river up to elevation 412, which is pool level. On a recent occasion when I was on board the maneuver boat the wickets were being lowered on a rising river with the water at the top of the wickets, and no difficulty whatever seemed to exist in such operations. For purposes of information I directed that one of the wickets be raised, which was done as easily as it had been lowered. In conversation with the overseer in charge of the work it developed that no difficulty in raising these wickets with the water practically at pool level occurred, except in the case of the last three or four adjacent to the pier.

The wickets of the Chanoine pass are of wood and are rotting, considerable damage already having resulted, and it will not be long before it will be necessary to replace these wickets. The Boulé gates are also of wood and have to be repaired and renewed constantly. This is, of course, not difficult in this case, because the gates can be readily removed and the rotten pieces taken out and replaced.

In designing this dam it was intended to regulate the pool by the Boulé sections, but in practice the Chanoine pass is used whenever it is seen that the rise can be controlled by the Chanoine section. If a greater length of dam must be lowered the long section of the Boulé is removed and only when the whole dam must be lowered are the short sections operated, in which case the short sections of the Boulé are lowered first, then the long section, and last the Chanoine pass. It will be seen by the above that the operation of this dam is very unsatisfactory and that it is difficult, expensive and dangerous; that on occasions sections have been caught by rises, and while no part of the dam has as yet been carried away it may be that damage from this cause will result. One is therefore forced to the conclusion that it would be advisable to take advantage of any opportunity that may arise to replace this dam by one more simple in construction and of operation, if the replacement can be done without undue cost to the United States.

THE PROJECT FOR THE IMPROVEMENT OF THE OHIO RIVER.

The present project was adopted by the act of Congress dated June 25, 1910, and may be described in few words as follows: It provides for 9 feet navigable depth in the river from its head at Pittsburgh, Pa., to its mouth at Cairo, Ill., a distance of 967 miles, by the construction of fifty-four* locks and dams (including No. 41 at Louisville); the locks are to have an available length of 600 feet and a width of 110 feet; the dams are to be of some movable type with lift of from 7 to 9 feet except at No. 41, where present maximum lift is 34 feet. The dams are to be movable, so as not to interfere with open river navigation at moderate stages of the river. In general, they consist of Chanoine navigable passes 600 to 800 feet long with Chanoine weirs varying in length at the different sites from 72 to 600 feet. Above Louisville from one to three bear traps are included, varying in length from 50 to 102 feet each. Below Louisville bear traps will not be needed and the Chanoine sections will be extended by fixed masonry weirs with crests 1 foot below upper pool level. The pass wickets are from 16 to 18 feet high, and weir wickets generally 11 feet 9 inches high. The pass wickets are raised and lowered from maneuver boats but service bridges are provided for the weirs.

By the retention of the present dam at Louisville (No. 41) in the project, with its crest only 10 feet above the pass sill and 9 feet above the bottom of the canal, dam No. 40, the next dam above Louisville, must have its sill at approximately the same elevation to provide 9 feet at the lower entrance of the locks. The lift of No. 40 is to be obtained by using wickets 16 feet 9 inches high. The pool to be created above No. 40 will extend 25 miles to Florence, Ind. It will be seen therefore that by raising the pool above the Louisville dam 6 feet by using longer wickets, the pool would have the same level as the proposed pool for No. 40, and therefore the latter dam could be eliminated and the pool due to No. 41 with increased height would extend to Florence, a distance of 75 miles from Louisville. The Board of Engineers for the Ohio River has decided to recommend this change and therefore all new work at Louisville is being planned to provide for the new pool at elevation 418.

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*One dam, No. 42, has since been eliminated by adjusting the lifts of the dams from 41 to 48, inclusive.

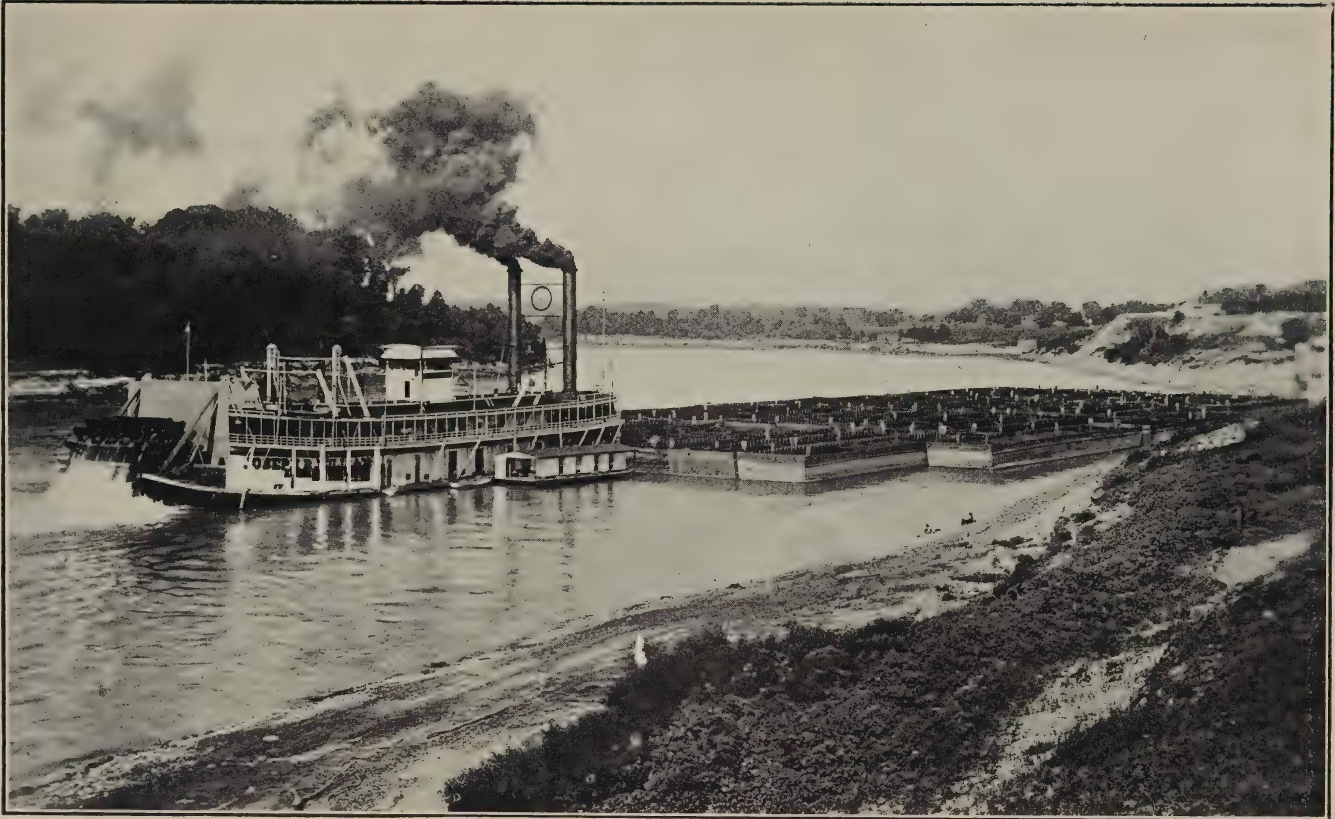
NEW WORK AT LOUISVILLE.

Much of the traffic on the Ohio consists of coal passing downstream in coal boats and barges arranged in tows directed by stern wheeled steamboats.

The ordinary coal boat, capacity 1,000 tons, is 26 feet wide by 175 feet long; coal barges, capacity 500 tons, are 130 feet long by 24 feet wide. Of the total present tonnage, of which record is made at Louisville, about 90 per cent is coal brought down the river in tows. The coal boats and barges are assembled at Pittsburgh and in the mouth of the Kanawha River awaiting a sufficient stage of water known as coal tow stage, which is about 15 feet in the upper river. These tows then start down the river floating with the current, being pushed and directed by the stern wheel tow boat until the tow reaches Louisville where it has to be broken up to pass through the locks or at high stages passes without breaking up through the Indiana Chute. Below the locks a number of these tows are combined into a large tow to be taken down the river to Mississippi River points.

The tows from Pittsburgh to Louisville average from fifteen to twenty coal boats and barges. When the river is improved by the construction of the locks and dams in accordance with the existing project, it is expected that the coal will move out at any time during the year, passing through the locks during the season when the dams are up. Because of the difficulty and cost of breaking up and reassembling these tows, large locks had to be provided, and the dimensions 600 feet by 110 feet were selected, which will allow four coal boats abreast and three in line, or twelve boats to a lockage. It is supposed that when the improvement is completed the tows will be arranged so as to be readily broken up into a number of sections of suitable size to pass through the locks.

The present canal at Louisville is 86½ feet wide and the locks are 348 feet long (available length) by 80 feet wide. It is possible at present to lock through only two coal boats or six barges at a single lockage. The Louisville locks and canal would necessitate the breaking up of these coal fleets into sections much smaller than could pass through the other locks. To improve the capacity of the canal and locks and standardize the system it was determined, first, to build a new single lift lock, alongside of the two locks now



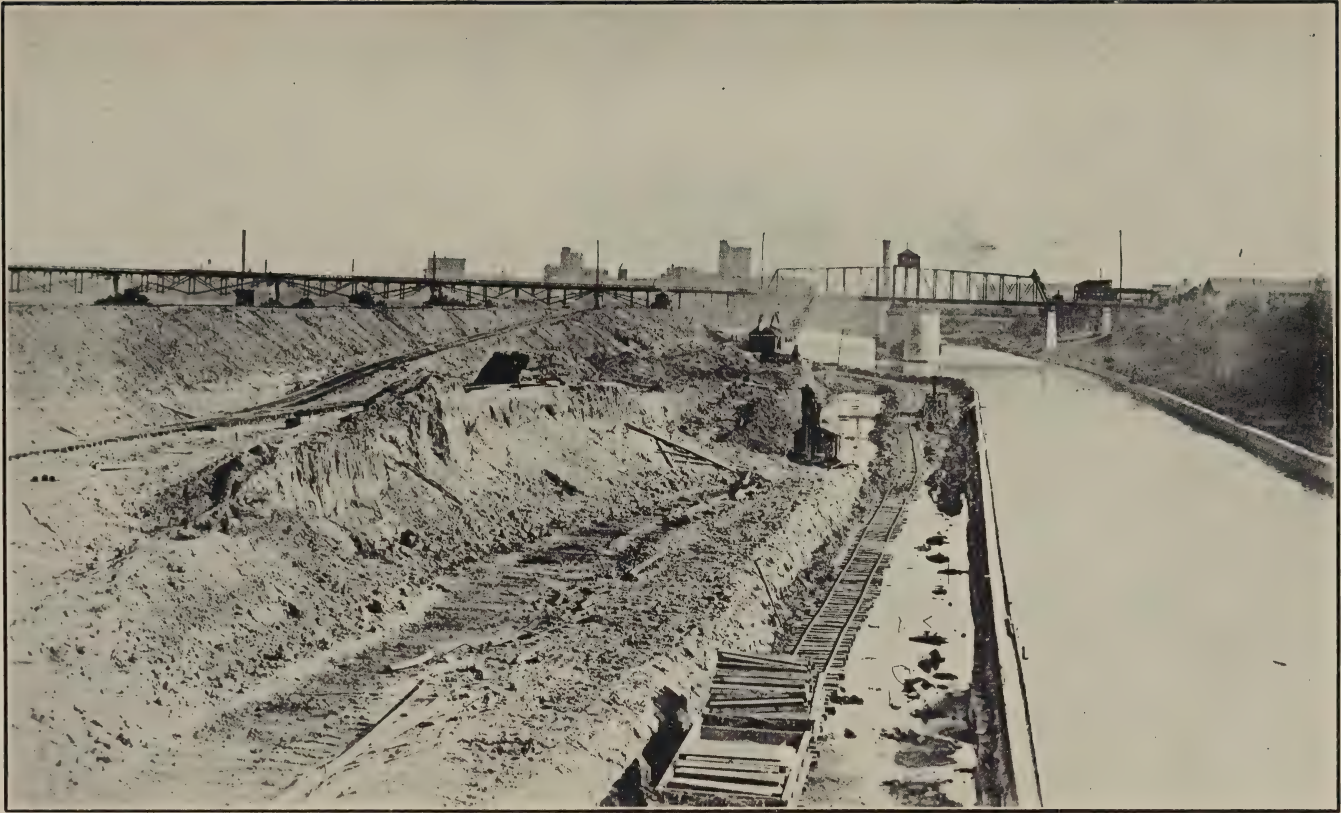
Steamer with Tow of Empty Coal Boats.

in commission, having the same dimensions as the other Ohio River locks, namely 600 feet by 110 feet, with a lift sufficient to take care of the whole head at the falls; and second, to widen the canal to 200 feet between perpendicular walls. With the present conditions the difference of low water head is 27 feet, but this must be increased by the increased depth of the upper pool due to the dam which is 7 feet, making the total lift (with low water below the lock and pool water above) 34 feet. This is the maximum lift under present conditions because as the river rises the lower pool rises more rapidly than the upper pool and the slope over the falls is decreased, but this maximum lift will be increased to 40 feet by the elimination of dam No. 40 and the raising of dam No. 41.

Before the idea of eliminating dam No. 40 by the construction of a new dam 41 had been considered a contract had been entered into for the construction of the new Louisville lock and plans and specifications had been made, but contract not entered into, for widening the canal to 200 feet between perpendicular walls. In view of the tentative decision to eliminate dam No. 40, changes in the plans and specifications for the latter work have been made to provide for the additional lift of 6 feet which will result from raising the crest of the dam that amount, and changes in the contract drawings for the lock must also be made.

WIDENING THE CANAL.

On April 19, 1913, contract was entered into between the U. S. and the Henry Bickel Co., of Louisville. for widening the canal from 86½ feet to 200 feet between perpendicular walls. This contract covers the following work: excavation of material from new canal prism; construction of new concrete canal wall and removal of old masonry of the present north wall; construction of a concrete pier for a new bridge at Eighteenth Street; removal of old bridge pier; concrete foundation for emergency dam to stop flow of upper pool through canal if lock gates should be wrecked; extension of discharge culvert for the dry dock; drainage culverts through the canal wall where required and a retaining and cut-off wall across the old locks (first ones built) below the guard gates to protect the filling to be placed in the old locks. This work includes the use of the excavated material to form an embankment on the north side of the canal to elevation 450, which is above the highest flood; the construction of a macadam roadway on top of this embankment from the 18th Street bridge to the



Widening Canal: Looking East toward Head of Canal from Eighteenth Street Bridge. Pennsylvania Railroad Bridge across Head of Canal shown.

shops and office at lock site; the filling of the old locks (three in series first built) and the area adjacent owned by the United States to make a larger area available for shops, etc.

The following gives the quantities and unit prices:

Items.	Quantities	Henry Bickel Company Louisville, Ky.	
		Unit Prices.	Totals.
Common excavation	*Cubic yds.* 770,000	$0.45	$346,500.00
Rock excavation	205,000	.90	184,500.00
Drilling bolt holes	*Linear ft.* 550	1.00	550.00
Stone paving	*Cubic yds.* 24	3.00	72.00
Reinforced concrete	490	20.00	9,800.00
Plain concrete	16,951	5.00	84,755.00
Channeling	*Square ft.* 48,300	.30	14,490.00
24-inch cast iron culvert	*Linear ft.* 385	8.00	3,080.00
16-inch cast iron culvert	24	6.00	144.00
Reinforcing rods	*Pounds.* 58,000	.05	2,900.00
Iron check posts	1,536	.10	153.60
Macadam roadway	*Sq. yds.* 12,200	.75	9,150.00
Total of bid	--------	-------	$656,094.60

The canal is to be excavated to elevation 400, the material to be excavated being partly earth and partly rock. The surface of the rock varies from elevation 400 near the locks to about 412 near the entrance, making an average rock excavation of 6 feet in depth. The rock to be excavated is a poor shale underlaid by limestone of varying hardness.

The concrete wall is to be built to elevation 420, or 8 feet above present pool water to allow the raising of the pool 6 feet by the projected new dam previously mentioned. This wall is to be founded on the rock, the face of which is to be channeled to the bottom of the canal, thus forming a continuous plane vertical surface from bottom of canal to top of wall.

The excavation between the old and new walls is being done in the dry behind the old wall which acts as a coffer, and after everything possible has been done in the dry, the old wall and rock upon

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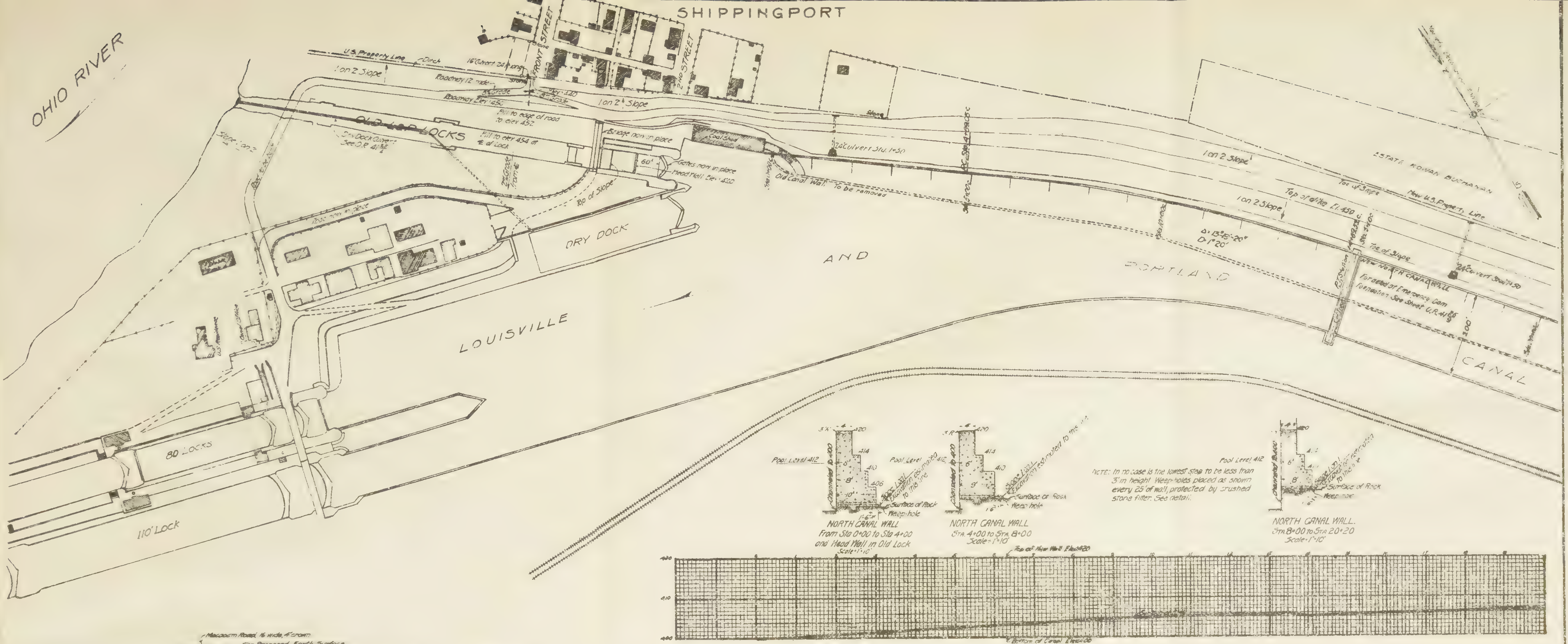
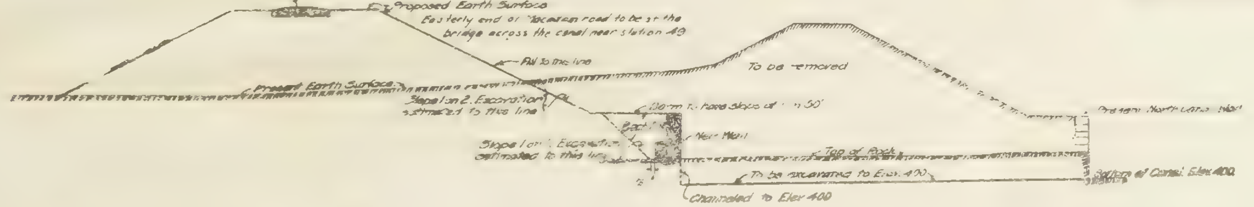
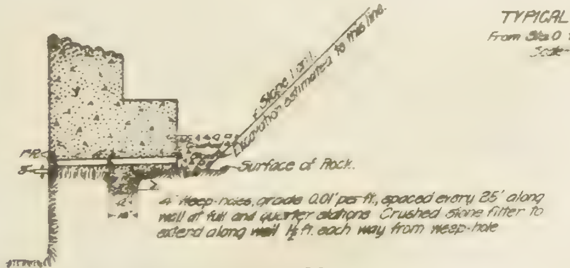

SHIPPINGPORT
OHIO RIVER
U.S. Property Line
Ditch
FRONT STREET
2ND STREET
1 on 2 Slope
Roadway 12' wide
Roadway Elev. 456
Fill to edge of road to elev 457
Fill to elev 454 at ⊄ of Lock
OLD 1&2 LOCKS
Dry Dock Culvert See O.R. 41/8
Bridge now in place
Gates now in place
Head Wall Elev 420
Coal Shed
Old Canal Wall To be removed
24" Culvert Sta 1+50
Top of Slope
DRY DOCK
AND
PORTLAND
LOUISVILLE
CANAL
ESTATE ROWAN BUCHANAN
New U.S. Property Line
Top of dike El. 450
Toe of Slope
Δ=13°15'20" D=1°20'
New North Canal Wall
For detail of Emergency Dam Foundation See Sheet O.R. 41/8
24" Culvert Sta 4+50
200'
80' LOCKS
110' Lock
Pool Level 412
Channeled to 400
Slope 1 on 1 Excavation estimated to this line
Surface of Rock
Weep-hole
NORTH CANAL WALL
From Sta 0+00 to Sta 4+00 and Head Wall in Old Lock
Scale 1"=10'
NORTH CANAL WALL
Sta. 4+00 to Sta. 8+00
Scale 1"=10'
NOTE: In no case is the lowest step to be less than 3' in height. Weep-holes placed as shown every 25' of wall, protected by crushed stone filter. See detail.
NORTH CANAL WALL.
Sta. 8+00 to Sta. 20+20
Scale 1"=10'
Top of New Wall Elev 420
Bottom of Canal Elev 400
420
410
400

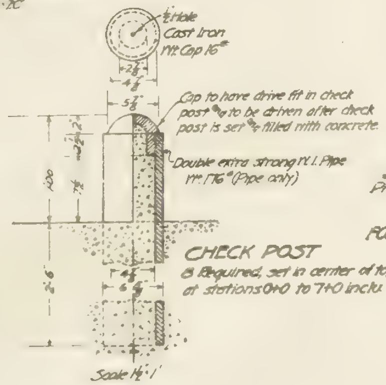
APPROXIMATE ROCK PROFILE
Hor. Scale 1"=100'
Vert. Scale 1"=10'


Macadam Road, 16' wide, 4" crown
Proposed Earth Surface
Easterly end of Macadam road to be at the bridge across the canal near station 49
Fill to this line
To be removed
Present Earth Surface
Slope 1 on 2. Excavation estimated to this line
Berm to have slope of 1 in 50'
Slope 1 on 1 Excavation estimated to this line
New Wall
Top of Rock
To be excavated to Elev. 400
Present North Canal Wall
Bottom of Canal Elev. 400
Channeled to Elev 400

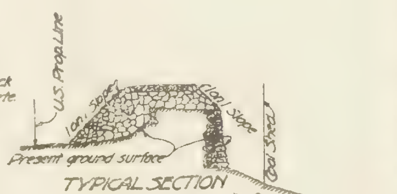
TYPICAL SECTION.
From Sta. 0 to Sta. 62+84.83
Scale 1"=20'


Slope 1 on 1
Excavation estimated to this line
Surface of Rock.
4" Weep-holes, grade 0.01' per ft., spaced every 25' along wall at full and quarter stations. Crushed stone filter to extend along wall 1½ ft. each way from weep-hole

DETAIL OF WEEP HOLE AND FILTER.
Scale ½"=1'


½" Hole
Cast Iron
Wt. Cap 16#
Cap to have drive fit in check post & to be driven after check post is set & filled with concrete
Double extra strong W.I. Pipe
Wt. 176# (Pipe only)
Scale 1½"=1'

CHECK POST
8 Required, set in center of top of wall at stations 0+0 to 7+0 inclu.


U.S. Prop Line
1 on 1 Slope
1 on 1 Slope
Coal Shed
Present ground surface

TYPICAL SECTION
FOR 270 FT. WEST OF STA. 0+0
Scale 1"=20'

Note: Dike to be solid rock fill for 370 ft west of sta 1+0.
Slope of north side of dike 1 on 1 for 560 ft west of sta 3+0.
All slopes steeper than 1 on 2 to be rock fill.
South slope 1 on 1 for 220 ft west of sta 0+0.

APPROXIMATE QUANTITIES

Sta	Excavation cu. yds			Fill cu. yds	Concrete Plain cu. yds	[illegible] sq. ft
	Earth	Rock	Old Wall			
West of Sta. 0+00				317830	300	–
0–5	45609	1545	1433	36403	2362	700
5–10	55817	6473	1166	45626	1866	2015
10–15	57839	11228	957	45120	1575	2857
15–20	64667	14874	542	40015	1589	4027
20–25	63357	16204	720	38305	1308	5630
25–30	62566	17912	651	36774	1256	3665
30–35	58745	20733	586	32947	[illegible]	4512
35–40	60403	22482	525	35038	[illegible]	5260
40–45	65118	22669	539	[illegible]	[illegible]	5355
45–50	76953	23127	535	22396	105	5730
50–55	75702	21166	635	[illegible]	84	[illegible]
55–60	79647	15162	[illegible]	24433	[illegible]	[illegible]
60–65	10187	[illegible]	538	[illegible]	[illegible]	[illegible]
65–70	NONE	NONE	NONE	68582	NONE	NONE
70–75				[illegible]		
75–80				59106		
80–84				32184	Rock fill	
TOTAL	770116	195253	9901	1006882	16551	[illegible]

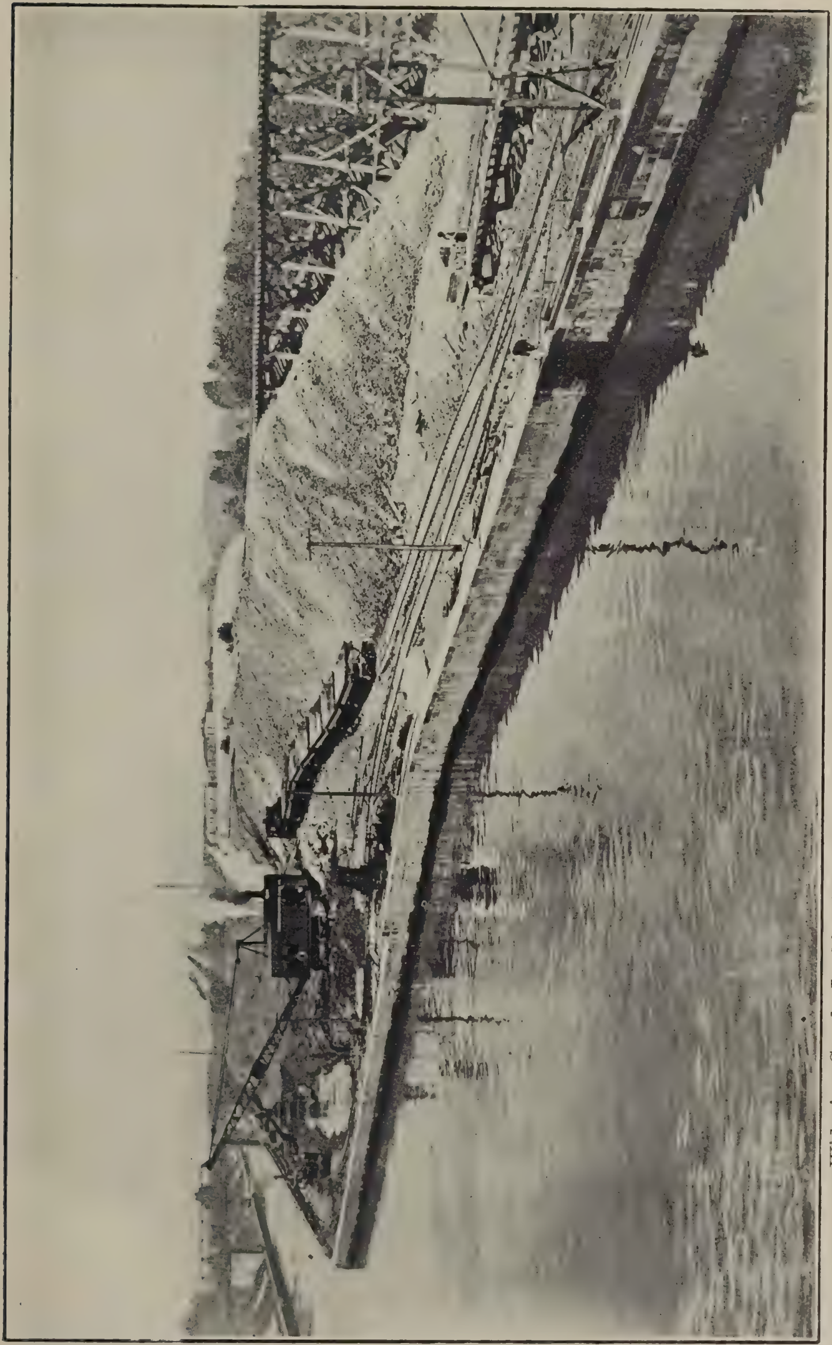
Note: The above fill is actual volume of completed fill. No allowance has been made for change of volume of materials in fill.

Plain concrete required for new bridge pier, emergency dam, head wall in old locks and pillars and head wall for dry dock culvert are included in the above quantities.

Station	[illegible]	
	[illegible]	[illegible]
[illegible]		[illegible]
[illegible]	[illegible]	20
2	[illegible]	[illegible]
[illegible]	[illegible]	20
4	[illegible]	25
[illegible]	[illegible]	30
[illegible]	16	35
[illegible]	17	40
8	18	40
9	19	40
[illegible]	20	40
11	21	40
12	22	40
13	23	40
14	24	40
15	25	40
5-20	25	40

OHIO RIVER
LOCK AND DAM NO. 41
CANAL
NORTH SIDE ENLARGEMENT
SCALE 1 In.=100 Ft.

FIGURE 5



Widening Canal: Looking West from Basin at Head of Canal. Eighteenth Street Bridge shown.

which it rests will be excavated in the wet. For details of the work see typical sheet (Fig. 5).

In this work the contractor is using the following plant:

Two Lidgerwood Drag Line Excavators, Class B-F, 70-foot boom, 2-yard dipper, rack-and-pinion continuous swing, mounted on single track.

One Marion Steam Shovel, Model 61, 2½-yard dipper, standard gage track, 165,000 pounds working weight.

One Thew Automatic Revolving Shovel, Type 1, mounted on traction wheel truck, 1 yard dipper.

One Thew Automatic Revolving Shovel, Type 1, mounted on traction wheel truck, ⅞ yard dipper.

Four Porter Locomotives, Class B-S, 14 by 20 inch cylinders, 40-inch drivers, standard gage, weight 40 tons.

Twenty-four Western Air Dump Cars, 12-yard capacity, wooden bodies, steel lined, standard gage.

One Ingersoll-Rand Channeler, Monitor H-8, roller guide, three-bit gang.

One Ingersoll-Rand Steam Wagon Drill, Class H-64, 3½-inch hole.

One Oliver Spreader, hand-power.

One Morris Motor-driven Centrifugal Pump, 12-inch discharge and 14-inch suction.

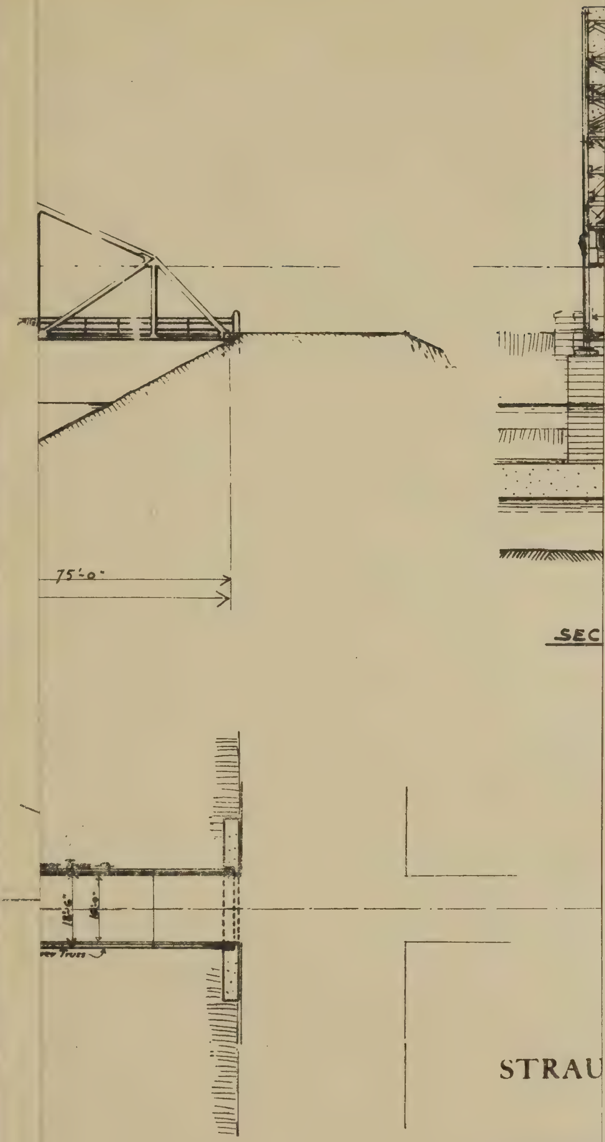
An additional channeler has been ordered,Type Sullivan Duplex, Class VW-61, cross-head guide, and a motor-driven air compressor to run hand drills will be installed as soon as rock excavation is well started.

The construction of the wall has not yet begun, but the contractor proposes to use a Smith, No. 2, ½-yard mixer, mounted on a flat car running along the embankment north of the wall. Material will be loaded on the cars by clam-shell from the material track running along the wall. Blaw steel forms in 40-foot sections will be used for the construction of this wall.

The water within the coffer is being handled at the present time by a 6-inch Nye pump; as the area becomes greater it is proposed to install a motor-driven centrifugal pump, 12-inch discharge and 14-inch suction.

BRIDGE PIER AND BRIDGE.

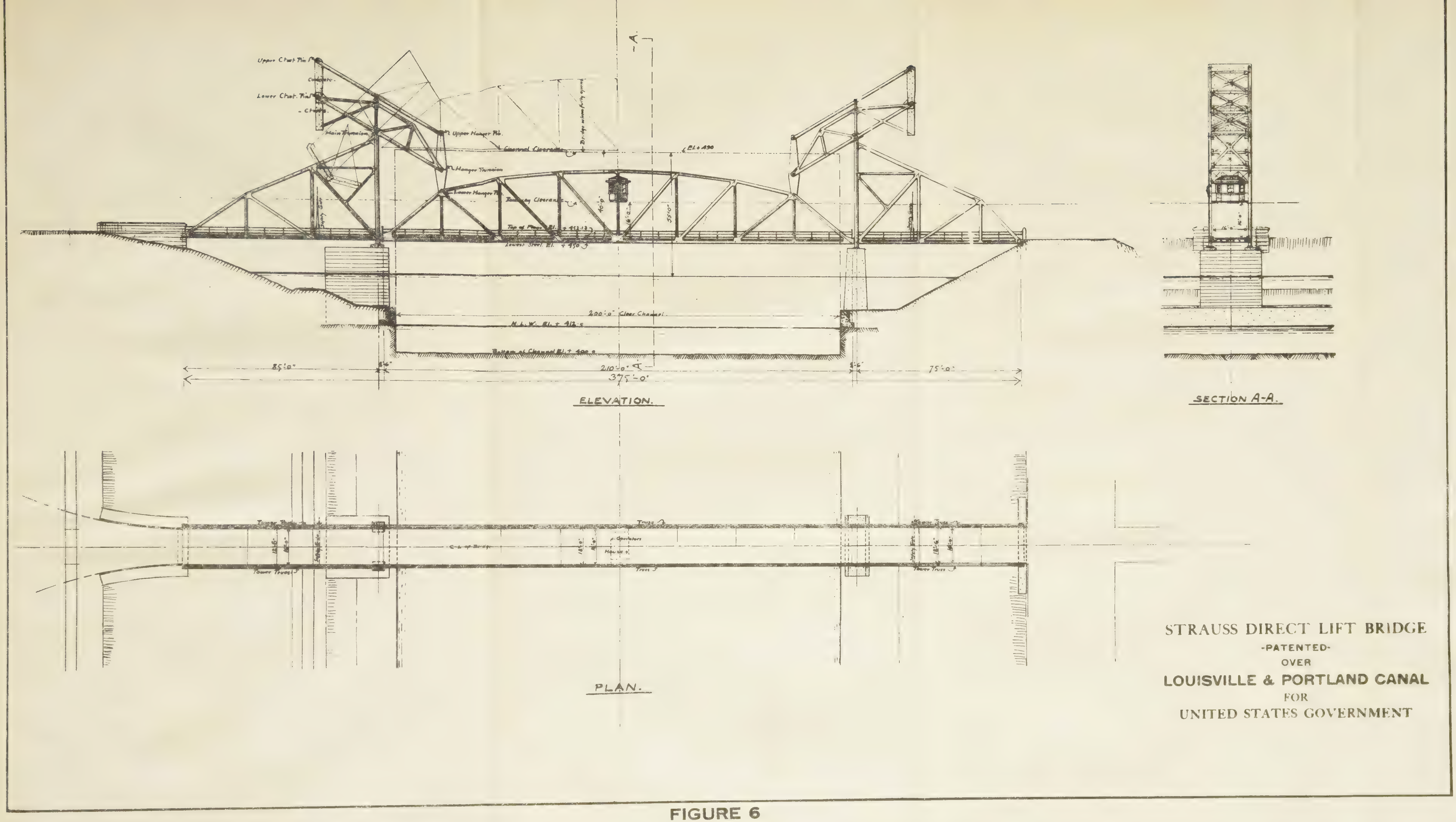
The bridge pier to be constructed under this contract is for a new bridge at 18th Street, which will replace the present one. The old south pier will be used for the south pier of the new


75'-0"
18'-6"
16'-0"
SEC

STRAU

LOUISV

UNITI


Upper Cbut. Pin
Counterweight
Lower Cbut. Pin
Chains
Main Trunnion
Upper Hanger Pin
Hanger Trunnion
Lower Hanger Pin
Channel Clearance
Bridge when fully open
El. + 490
Roadway Clearance
40'-0"
16'-0"
55'-0"
Top of Floor El. + 453.13
Lowest Steel El. + 450
200'-0" Clear Channel
M. L. W. El. + 412.0
Bottom of Channel El. + 400.0
85'-0"
5'-6"
210'-0"
375'-0"
75'-0"
ELEVATION.
A
16'-0"
SECTION A-A.
Tower Truss
Truss
C. L. of Bridge
18'-6"
Operators House
PLAN.

STRAUSS DIRECT LIFT BRIDGE
-PATENTED-
OVER
LOUISVILLE & PORTLAND CANAL
FOR
UNITED STATES GOVERNMENT

FIGURE 6

bridge, but as the span must be increased from about 87 feet to over 200 feet a new north pier must be constructed and the old north pier must be removed.

The present bridge is a swing structure with unequal spans and the new one will be a single-span Strauss Direct Lift Bridge, the span being lifted by counterweighted levers attached at each end of the truss span and operated electrically by rack-and-pinions. (Fig. 6.) The design and specifications for the bridge are on hand, but the construction of the bridge does not form a part of this contract.

EMERGENCY DAM.

An emergency dam is to be placed in the canal about 2,500 feet above the locks. This dam will be used to stop the flow of water through the canal and locks in case the lock gates should be wrecked by accident.

The boats and barges using the canal and locks are of rather flimsy construction and it is believed that there is not much danger of accidents to gates from impact by such boats and barges, as no accident has occurred up to the present time. Nevertheless, some such accident is possible and without some means of stopping the flow through the locks the consequences might be very serious on account of the very swift current that would result. Even if no accident occurs, the dam will be very useful as a coffer to allow work to be performed in the forebay of the locks or on the guard gates.

The dam must be of such type that it will be available at any moment, will not be destroyed through non-use, and it must be possible to operate it when a very swift current is flowing through the canal. The swiftness of the current prohibits operation of the dam by a maneuver boat. A framed swing-bridge, such as is used on the Panama Canal, would be too expensive, and a consideration of all conditions led to the belief that the Boulé offered the least objections. As a result a type of Boulé has been designed, details of which are shown on Fig. 7. This dam will be operated from the trestles. As the depth of water might be as great as 20 feet, very strong trestles have to be provided, and for facility of operation their distance apart was limited to about 5 feet. The trestles when not in use lie one on top of the other behind the sill and below the bottom of the canal. These trestles are connected at intervals to a chain which passes to a winch on the north canal wall. By hauling in the chain a trestle is raised and after placing the cover plate the chain is disconnected and hauled in until the next trestle is in position. The trestles are thus raised in succession and the cover plates placed until the trestle bridge is completed.

Owing to the fact that the gates or wickets will be left on the bank for months and perhaps years at a time without much attention, steel was selected for the material to be used. To handle these wickets from the trestle bridge it becomes necessary to have some kind of crane or derrick. A locomotive crane capable of lifting about 7½ tons has been adopted for this use. The crane will habitually be used in the shop yards adjacent to the locks and when needed to operate the dam will be run down a track leading from the yards to a turn-table opposite the dam and then run out into position to perform its function. The cover plates carry the track in sections as part of each plate. The gates or wickets will be piled on the berm of the canal under a skeleton frame on which there will be differential pulleys to lift and place same on a flat car.

As it is supposed there is good rock for a foundation, a very simple sill only is required. As the head of water might be as great as 20 feet, it is necessary to hold the sill to the rock by means of tie rods, and these rods and the ones holding the trestles in place with a small concrete sill are all that are necessary for the foundation.

NEW BRIDGE AT HEAD OF LOCKS.

Besides the 18th Street bridge near the upper end of the canal, a bridge is also maintained over the head of the old locks and forms a part of the roadway to the town of Shippingport, north of the canal, and to the bottom lands between the canal and the river. The construction of a new lock, 110 feet wide, alongside of the old locks makes it necessary to replace the old bridge by a new one to span both locks, and the plans provide for the removal of the old bridge and the construction of a single swing bridge of equal arms, the pivot pier being constructed between the old and new locks. The length of the bridge will be 275 feet over all and the type is that of the latest highway swing bridges.

NEW LOCK.

The new lock is to be located alongside and south of the present locks. (See Fig. 8.)

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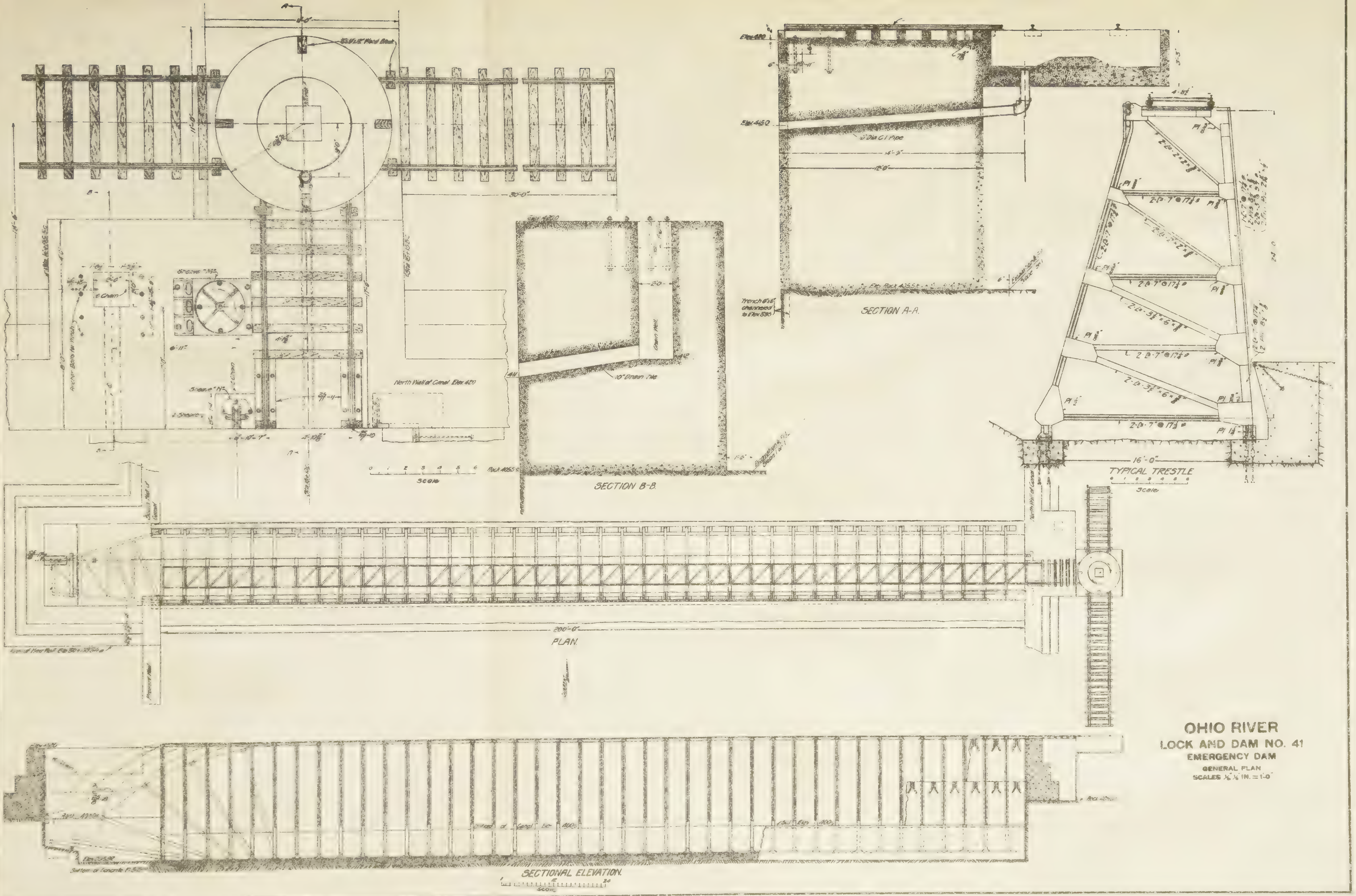
North Wall of Canal Elev. 420
10" Drain Tile
Drain Well
Scale
Rock 406.5±
SECTION B-B
Elev. 450
Elev. 420
5" Dia. C.I. Pipe
Trench 6x6 channeled to Elev. 395
Elev. Rock 405.5±
SECTION A-A
4'-8½"
2-[8-7"@17¼#
2-L's-3½"×6"×⅜"
Pl ⅜"
16'-0"
TYPICAL TRESTLE
Scale
200'-0"
PLAN
SECTIONAL ELEVATION
Rock 400±
Sill Elev. 400
Bottom of Concrete 397.5±
Scale
OHIO RIVER
LOCK AND DAM NO. 41
EMERGENCY DAM
GENERAL PLAN
SCALES ⅛" ⅛" IN. = 1'-0"

FIGURE 7

Dimensions and Details.	*Feet.*
Width	110
Length between quoins	681
Length available	600
Elevation lower sill	372
Elevation upper sill	401
Lift, low water above and below (dams down)	27
Lift, low water below, present dam up	34
Lift, low water below, proposed new dam up	40

Lower gates: horizontal arched, backed by heavy diagonal bracing, (Keokuk type).

Upper gates: vertically framed.

Guard gates: vertically framed.

Filling and emptying conduits side entrances and exits, main conduits circular, branch conduits, rectangular.

Valves: main conduit, rectangular 10 by 12 foot Stoney gates, operated by hydraulic cylinders, oil pressure; branch conduits, butterfly valves 4 by 6 foot, vertical axes, operated by hand—to be used only in emergency.

Gates operated by direct-acting hydraulic jacks, oil pressure 500 pounds per square inch.

Contract for the construction of this lock and the widening of the canal above the lock for the approach basin and the excavation of a channel below the lock was entered into with the Ohio River Contract Company in December, 1911. The following table shows the items, unit prices and total of their bid.

Items.	Quantity.	The Ohio River Contract Co. Evansville, Ind.	
		Unit Prices.	Totals.
Cofferdam, elev. 400.7	300 lin. ft.	$12.50	$3,750.00
Cofferdam, elev. 446.7	200 lin. ft.	40.00	8,000.00
Common excavation	876000 cu. yds.	.35	306,600.00
Rock excavation	293000 cu. yds.	.90	263,700.00
Drilling bolt holes	4280 lin. ft.	.50	2,140.00
Fill	250000 cu. yds.	.15	37,500.00
Channeling	101300 sq. ft.	.15	15,195.00
Riprap	75 cu. yds.	1.00	75.00
Stone paving	535 cu. yds.	4.00	2,140.00
Concrete piles	660 lin. ft.	3.00	1,980.00
Oak timber	11500 ft. b. m.	80.00	920.00
Concrete	65565 cu. yds.	*4.70	*308,155.50
		*5.00	327,825.00
Concrete paving	1231 cu. yds.	7.00	8,617.00
Structural steel	303500 lbs.	.05	15,175.00
Reinforcing rods	150 lbs	.05	7.50
Forgings, wrought iron included	33200 lbs.	.05	1,660.00
Bolts, etc.	11000 lbs.	.05	550.00
Iron castings	45800 lbs.	.05	2,290.00
Steel Castings	213400 lbs.	.07½	16,005.00
Bronze	60 lbs.	1.00	60.00
Pipe, 7-inch	19 lin. ft.	1.50	28.50
Pipe, 6-inch	255 lin. ft.	1.50	382.50
Pipe 5-inch	780 lin. ft.	1.50	1,170.00
Pipe, 4-inch	1090 lin. ft.	.75	817.50
Pipe, 3-inch	8210 lin. ft.	.75	6,157.50
Pipe, 2-inch	2000 lin. ft.	.75	1,500.00
Tile Drain	170 lin. ft.	.75	127.50
Small power house	4 No.	1000.00	4,000.00
Macadam roadway	10800 sq. yds.	.75	8,100.00
*Total of bid (original)			$1,036,473.00
*Total of bid, if bond is reduced to 25 per cent of contract			1,016,809.50

During the past two years excavation has been carried on both in the wet and in the dry. Operation was begun by dredging to widen the basin at the head of the lock. Most of the excavation is in earth, but a small quantity of rock must be taken out and it is thought the old wall will be left as a coffer, the rock drilled and blasted in the dry and then excavated by dredging in the wet. A

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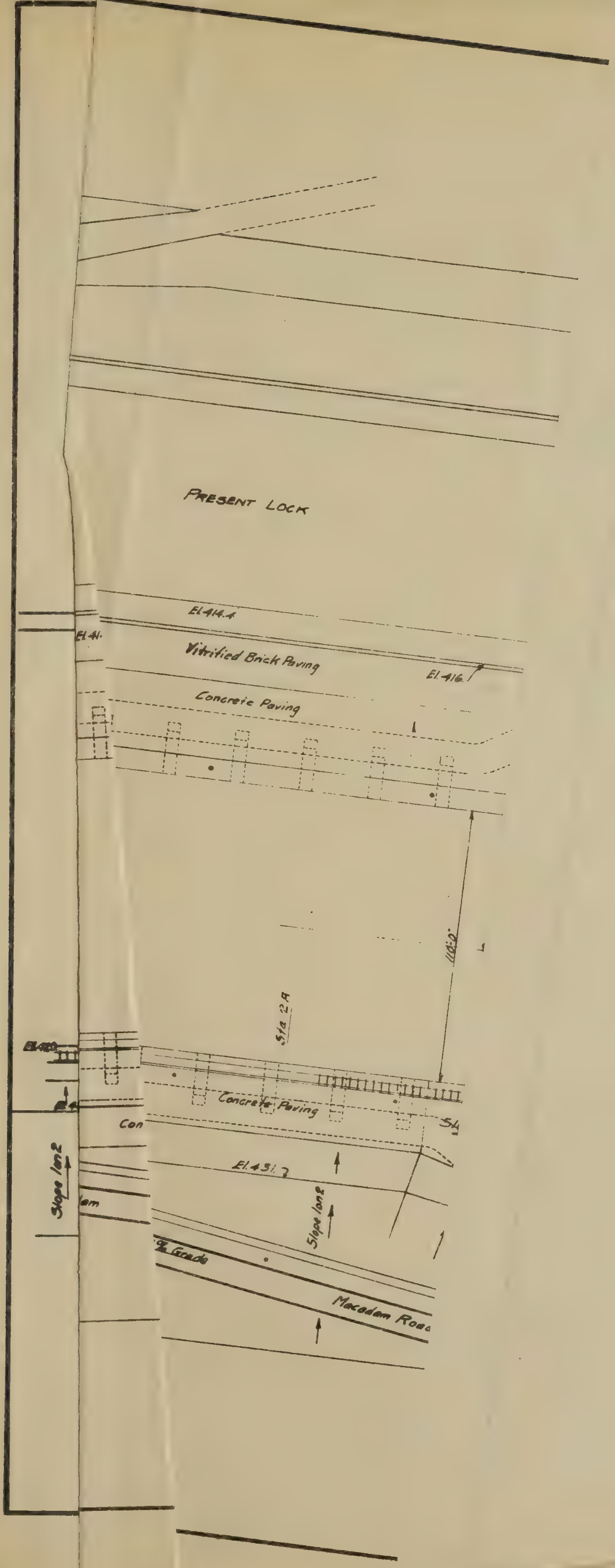
*The price bid for concrete was $5.00 per cubic yard if a 50 per cent bond be required of the contractor, or $4.70 per cubic yard if the bond be reduced to 25 per cent of the total consideration of the contract.


PRESENT LOCK
El.414.4
El.41.
Vitrified Brick Paving
El.416.
Concrete Paving
110'0"
Sta 12A
El.420
Concrete Paving
Con
St
El.431.7
Slope 1on2
Slope 1on2
am
% Grade
Macadam Road

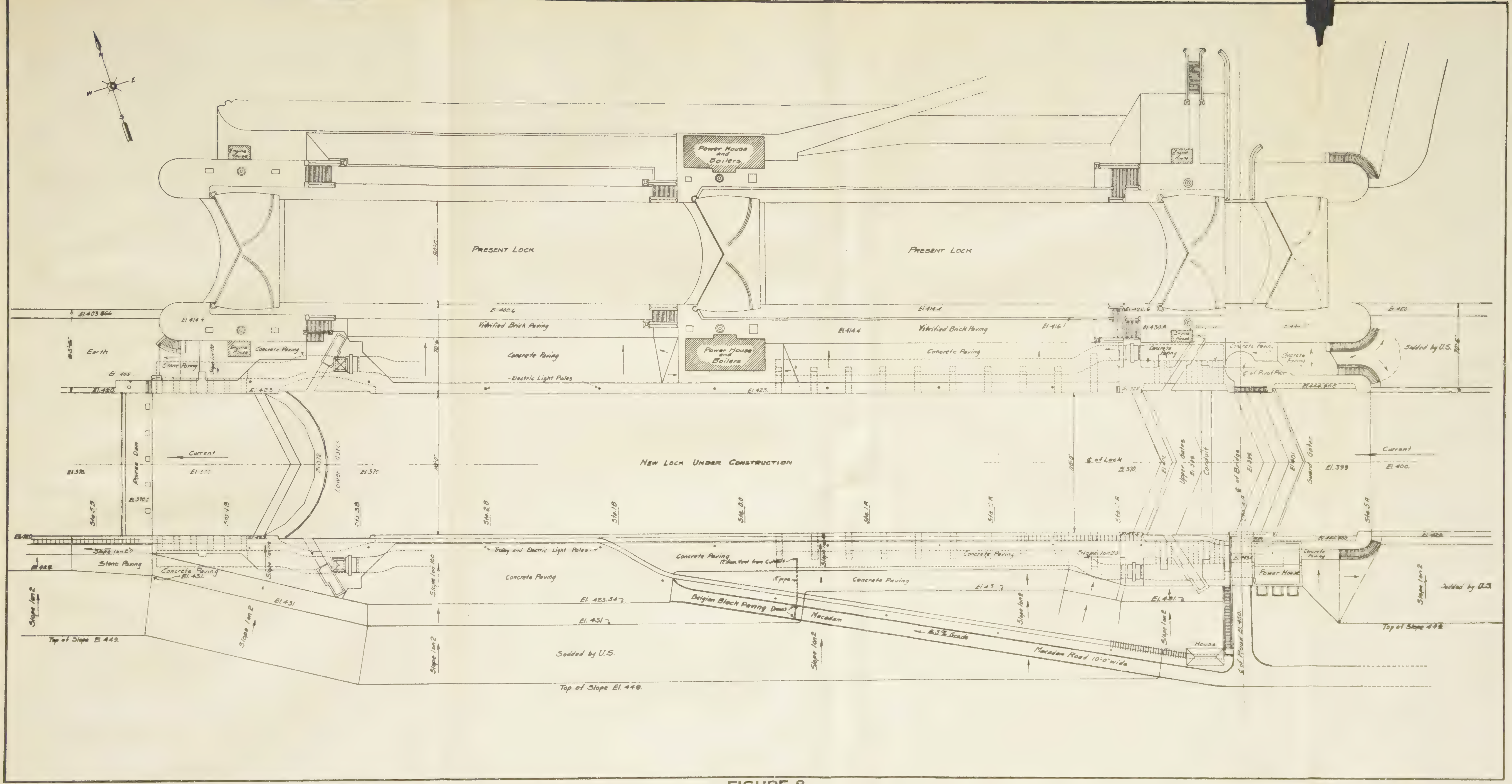
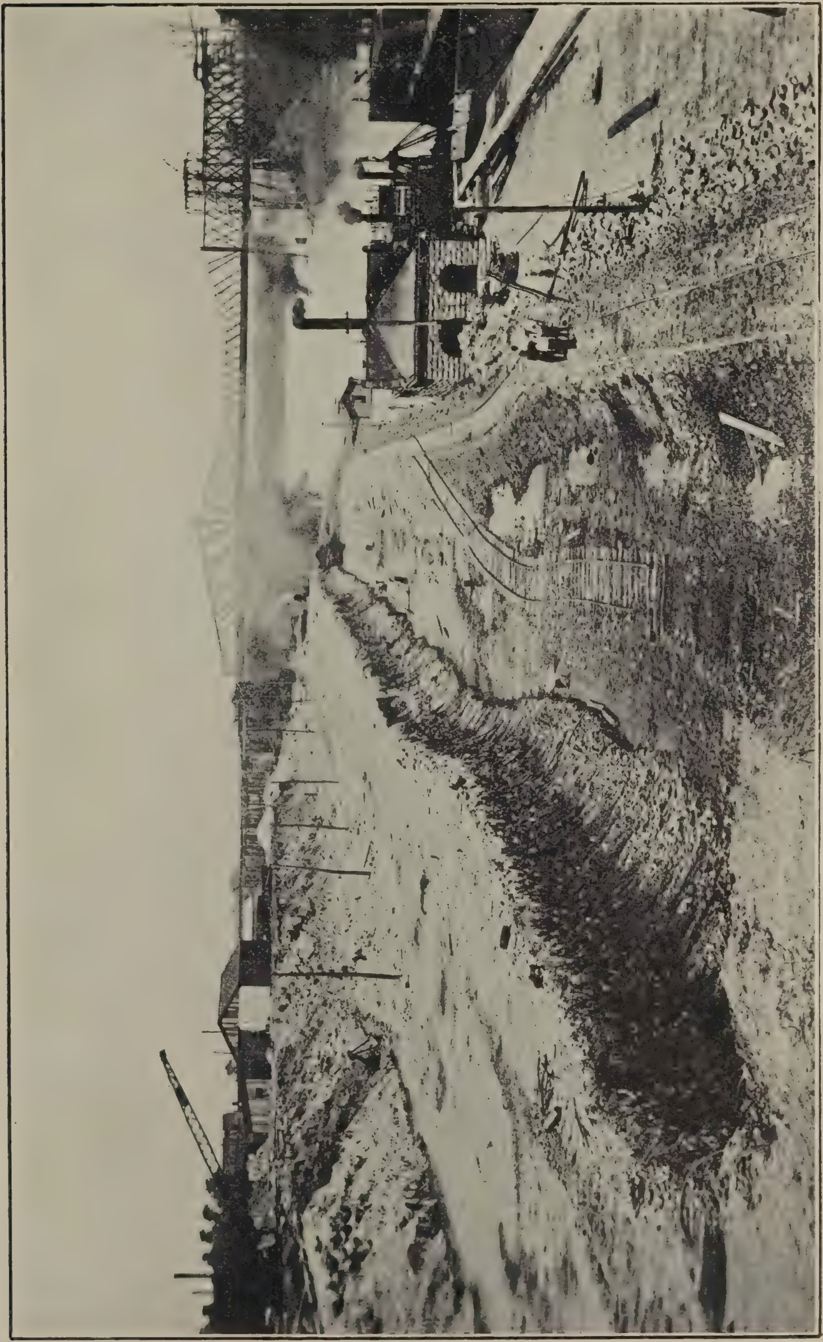

N
E
W
S
Engine House
Power House and Boilers
Present Lock
Present Lock
Engine House
El. 403.866
El. 414.4
El. 400.6
El. 414.4
El. 414.4
El. 416.1
El. 422.6
El. 430.8
El. 420
Vitrified Brick Paving
Vitrified Brick Paving
Earth
6'5"
Engine House
Concrete Paving
Stone Paving
Slope 1 on 100
El. 405
El. 420
El. 423
Concrete Paving
Electric Light Poles
Power House and Boilers
El. 423
Concrete Paving
Concrete Paving
Concrete Paving
℄ of Pivot Pier
Sodded by U.S.
70'6"
El. 425
El. 422.905
Current
El. 370
Poiree Dam
El. 370
El. 370.5
El. 372
Lower Gates
El. 370
80'0"
70'6"
110'0"
New Lock Under Construction
℄ of Lock
El. 370
El. 401
Upper Gates
El. 399
Conduit
℄ of Bridge
El. 399
El. 401
Guard Gates
El. 399
Current
El. 400.
Sta. 5B
Sta. 4B
Sta. 3B
Sta. 2B
Sta. 1B
Sta. 0.0
Sta. 1A
Sta. 2A
Sta. 3A
Sta. 4A
Sta. 5A
El. 420
El. 422.905
El. 420
Slope 1 on 20
Stone Paving
El. 428
Concrete Paving
El. 431.
Slope 1 on 100
Trolley and Electric Light Poles
Slope 1 on 100
Concrete Paving
Concrete Paving
Concrete Paving
Concrete Paving
Slope 1 on 20
Concrete Paving
Power House
Sodded by U.S.
Slope 1 on 2
El. 431.
El. 423.54
El. 431
Belgian Block Paving
Drains
Macadam
El. 43
El. 431.
6.5% Grade
Macadam Road 10'0" wide
House
℄ of Road El. 450.
Slope 1 on 2
Slope 1 on 2
Slope 1 on 2
Slope 1 on 2
Slope 1 on 2
Slope 1 on 2
Top of Slope El. 449.
Sodded by U.S.
Top of Slope El. 448.
Top of Slope 448

FIGURE 8



Lock Pit Excavation; Looking West, Present Locks on Right. June 1, 1912. (See page 587.)

new concrete canal wall is to be constructed around the widened section and the old wall removed. This work is exactly similar to that described under the head "Widening the Canal," and presents no interesting features. An ordinary dredging plant consisting of dipper dredges, scows, and stern-wheel steamboat is being used.

Near the head of the lock a portion of the natural bank has been left in place to act as a dam, below which the lock pit is being excavated in the dry. The material to be excavated consists of silt and sand above elevation 400, below which to approximately elevation 385 is poor shale and the remainder to bottom of lock at elevation 371 is hard stratified limestone. As so much of the excavation for the lock pit is in rock, it was thought unnecessary to carry the walls to the bottom of the pit. Provision was made for channeling the rock, allowing for a 3-foot face wall of concrete to be held against the rock by steel rods and only such rock was to be excavated as might be found unsuitable for foundation of the walls. In this way a large saving of concrete was to be made. Excavation in the pit has been carried to approximately elevation 390, and from the appearance of the rock thus far uncovered it is probable that the walls will have to be carried much deeper than was contemplated.

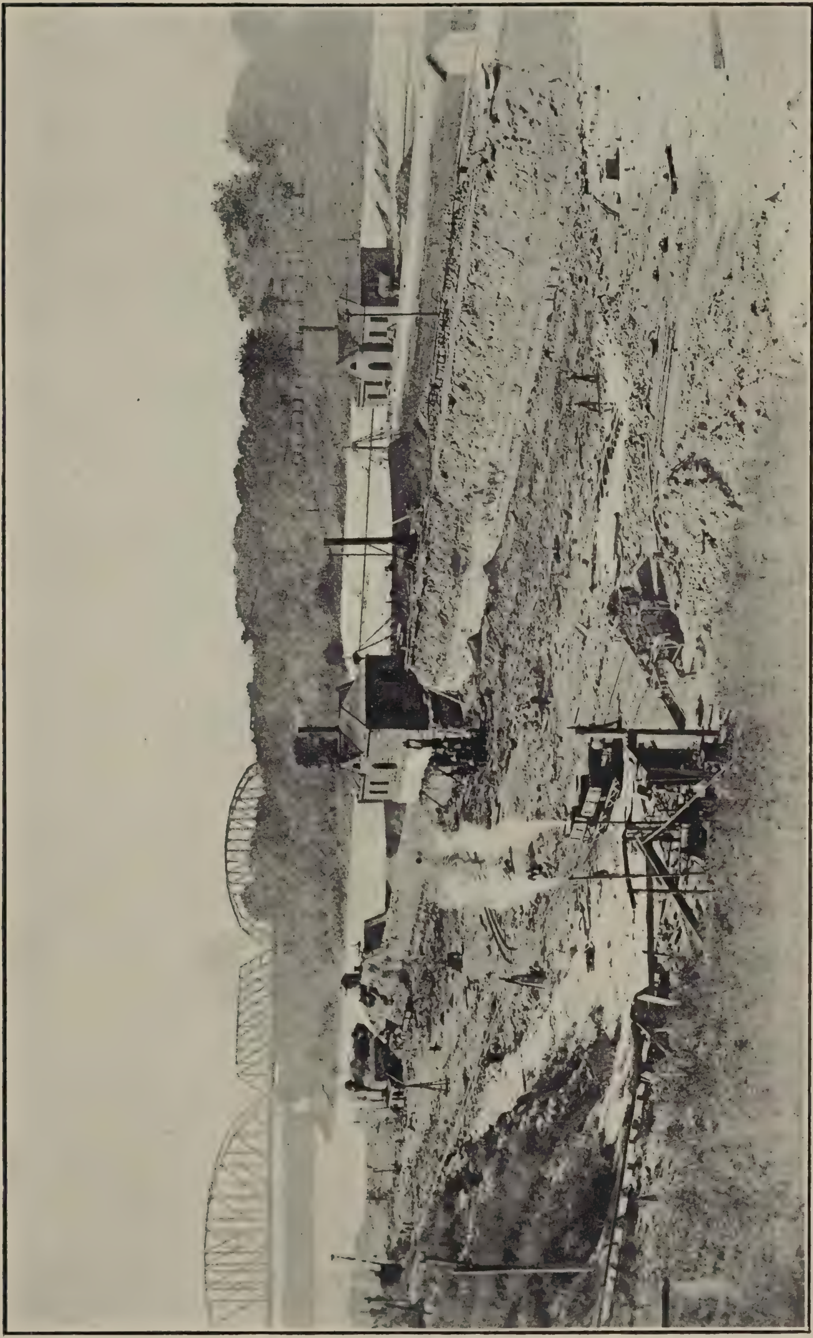
The increased lift due to the proposed new pool requires increasing the height of the walls, gates, etc., so that the walls must be redesigned, but the sections can not be determined until the excavation uncovers more of the rock and its suitableness for foundation is proven.

The excavation of the pit has been carried on in the dry with the usual plant, such as steam shovel, clam-shells, etc., emptying into cars which were at first hauled out of the pit by locomotives, but later as the excavation became deeper by hoisting engines and cable hauling up a steep inclined track.

VALVES.

The lock will be filled and emptied through the side walls and the arrangement of conduits, valves, etc., is the same in both walls.

Water is taken from the forebay through 6 rectangular conduits 6.25 by 4 feet, connected with a circular conduit 12.7 feet in diameter, which carries the water past the gate and distributes it along 278 feet of lock through ten rectangular conduits 5 by 3.25 feet, spaced 28 feet center to center and opening through the side wall at the bottom of the lock. In emptying the lock the water will pass through ten rectangular conduits 5 by 3.833 feet



Lock Pit Excavation. Present Locks on Right. Middle Gates show between Operating Houses. (See page 588.)

into a circular conduit 12.7 feet in diameter and thence to the tailbay through six rectangular openings 6.25 by 4 feet.

In the contract drawings the valves were placed in the rectangular conduits above the upper gate and below the lower gate and as shown are the standard type adopted for the other Ohio River locks, namely, the butterfly valve with vertical axis, designed to withstand the much greater head than is found elsewhere on the Ohio. These valves were to be operated by hydraulic jacks, using oil for fluid, to be pumped by compressed air. There were to be four separate compressed air plants, two on each side of the lock opposite the gate recesses. No safety appliances had been designed to shut off the flow of water from upper to lower pool if one or more filling valves and one or more emptying valves were to be injured or were to fail at the same time.

After the contract had been made and the material for the butterfly valves had been purchased by the contractor, it was decided to provide for an additional head of 6 feet, and it was also decided that the proposed valves were not satisfactory. Experience with large butterfly valves in other locks where the head is not more than 20 feet has led to the expectation that the valves might slam during closing and be injured. Another grave objection to this type operated by compressed air is that when the pressure becomes sufficient they are liable to open at the same time to their full extent, allowing the rush of water under full head into the chamber, and it was feared that the commotion resulting from this flow of water might sink vessels passing through the lock. With sliding gates this objection is easily overcome, as they provide means for complete regulation of the flow through the conduits and consequently the degree of commotion in the lock. For these reasons and also the additional one that it was deemed advisable to provide for a duplication of the valve system, it was determined to place Stoney gates in the large conduits.

Inasmuch as the butterfly valves are on hand and partially paid for, they are to be installed for use in case of accident to the Stoney valves. They are to stand open habitually and will be operated by hand by means of worm gears operated by ratchet levers. Thus, if it is desired at any time to remove the Stoney valves for repairs the butterfly valves can be closed and the Stoney valve removed and the lock will not be put out of operation.

Four Stoney valves will be installed, two on each side in the main conduits near the gates. These valves will be placed in wells

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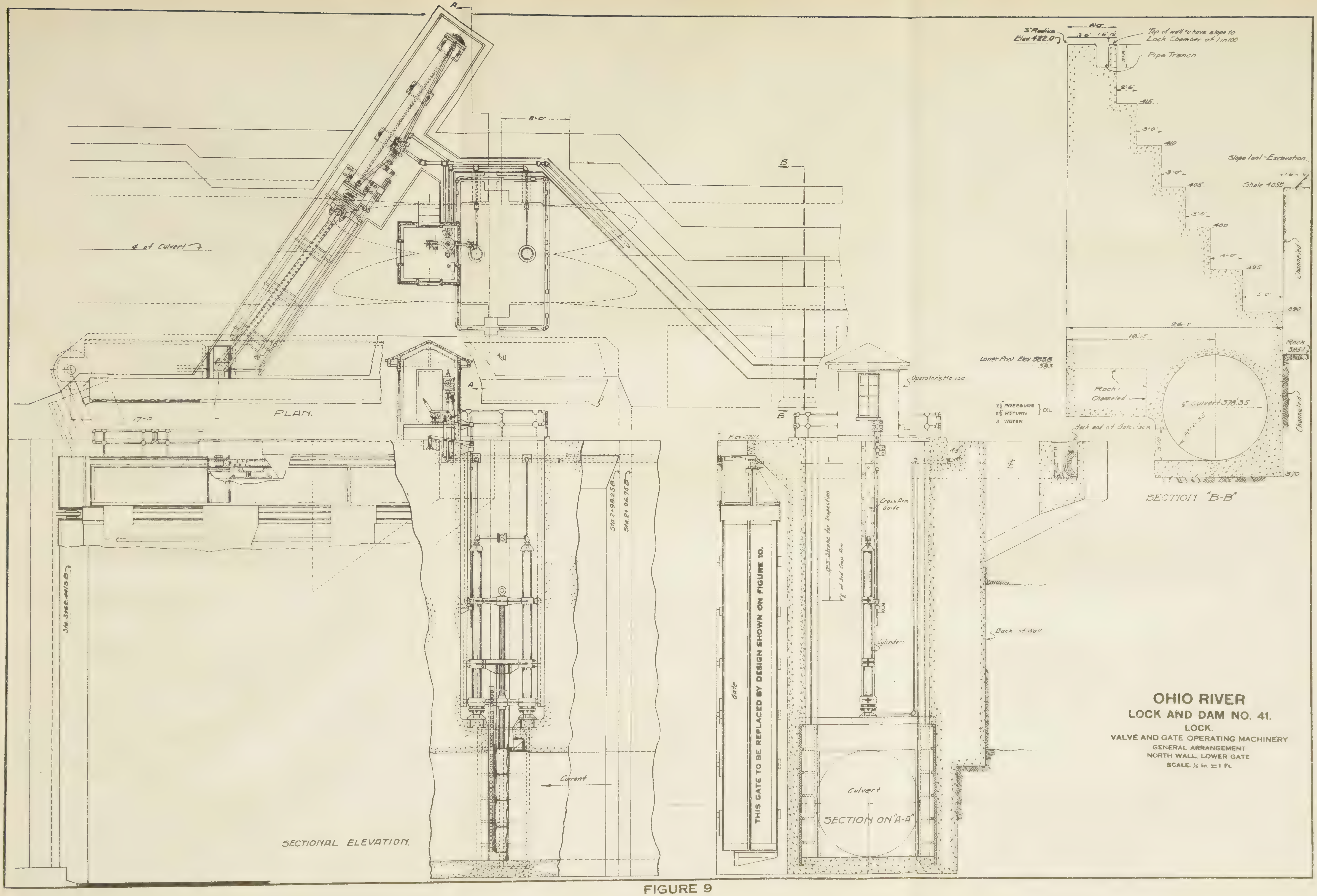

A
8'-0"
B
℄ of Culvert
PLAN.
17'-0"
A
Sta. 2+98.25 B
Sta. 2+96.75 B
Sta. 3+02.44 13 B
Current
SECTIONAL ELEVATION.
Operator's House
Elev. 422.0
Cross Arm Guide
17'-3" Stroke for Inspection
℄ of 3rd Cross Arm
Cylinders
Gate
Culvert
SECTION ON "A-A"
Back of Wall
2½" PRESSURE
2½" RETURN
OIL
3" WATER
Lower Pool Elev. 383.8
383
3" Radius
Elev. 422.0
8'-0"
3'-6"
1'-6½"
Top of wall to have slope to Lock Chamber of 1 in 100
Pipe Trench
2'-6"
415
3'-0"
410
3'-0"
405
3'-0"
400
4'-0"
395
5'-0"
390
Slope 1 on 1 - Excavation
Shale 405±
Channeled
26'-6"
18.15
Rock 385±
Rock Channeled
℄ Culvert 378.35
R. 6.35
3'-10
Back end of Gate Jack
Channeled
370
SECTION "B-B"

THIS GATE TO BE REPLACED BY DESIGN SHOWN ON FIGURE 10.

OHIO RIVER
LOCK AND DAM NO. 41.
LOCK.
VALVE AND GATE OPERATING MACHINERY
GENERAL ARRANGEMENT
NORTH WALL, LOWER GATE
SCALE: ¼ In. = 1 Ft.

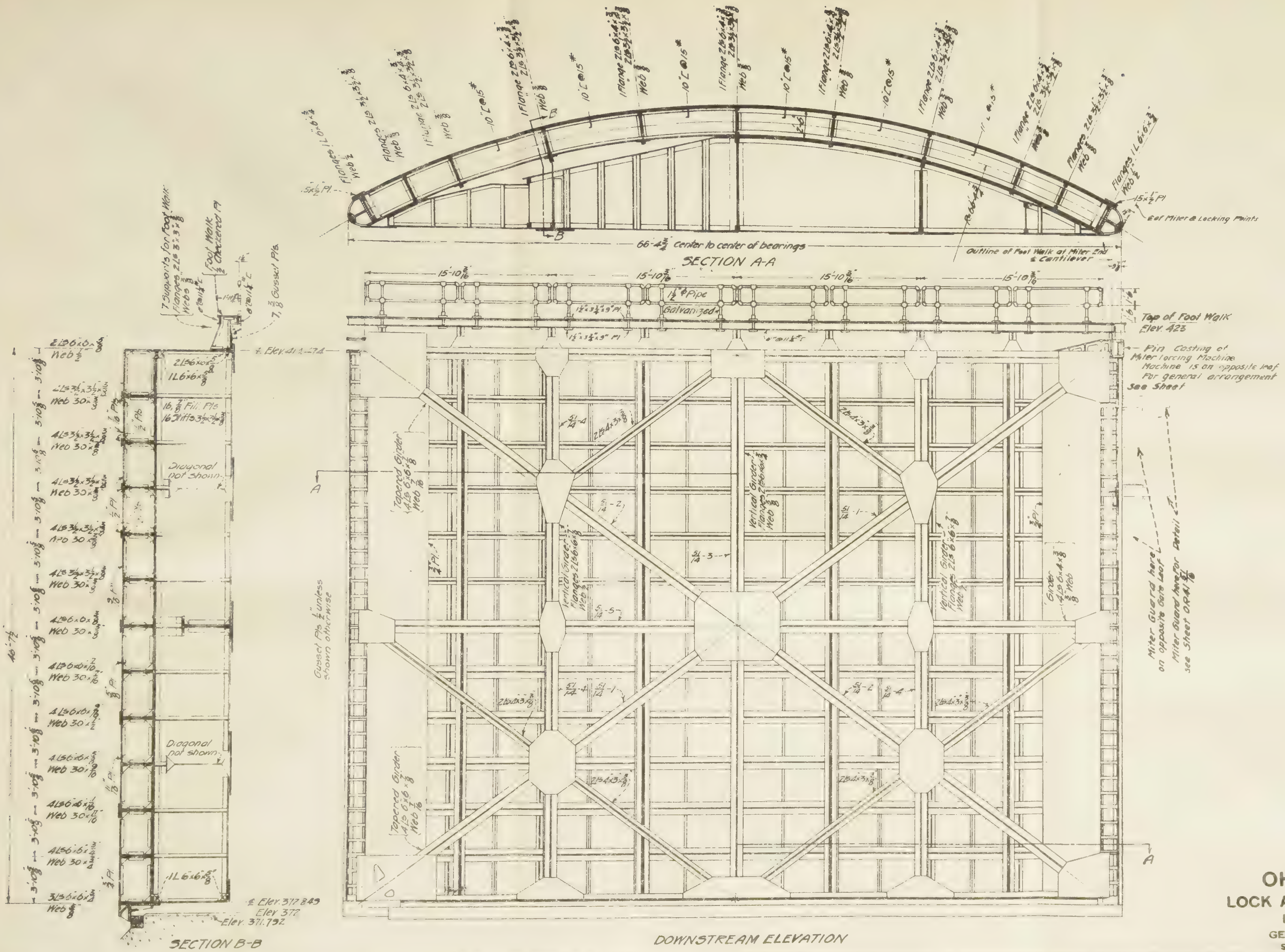
FIGURE 9

of such dimensions that the valves may be entirely removed to the top of the walls for inspection or repairs at any time. The circular cross section of the conduits adjacent to the Stoney gates is changed to rectangular and the conduit is lined with steel plates for several feet above and below the gates. Heavy castings for the valve seats are set into the concrete. The valves (see Fig. 9) move in a vertical plane on trains of rollers operating against these castings with seals similar to those used in the Panama Canal lock valves. The operation of these valves is very different, however, from those of the Panama Canal. The vertical stem extends upward from the top of the valve and is connected by cross-arms to cylinders. These cylinders work over fixed pistons or plungers, the latter being secured to the bottom of the well by large base castings bolted to horizontal I-beams in the concrete. The top flanges are 29.25 feet below pool level. The plungers and cylinders are sufficiently long to allow the valve to be raised above the floor of the well and ladders lead to the top of the lock walls to allow inspection and minor repairs to all parts of the valve when the valve is lifted to its extreme limit. An eyebolt is provided at the top of the main stem for lifting the valve out of the well to the top of the wall in case extensive repairs are necessary. These vertical pistons or plungers have a 1½ inch hole bored through the center of their entire length. Oil is pumped to the plungers where it enters at the bottom, passes upward through the central hole and presses against the cap at the top of the cylinders. The pressure is equalized in the two cylinders by a cross-connection to make up for any difference of pressure in the supply pipes. The cylinders with the stem and valve being free to move, slide vertically upward, the plungers being displaced by the liquid forced through them to lift the apparatus. These cylinders are held in position and attached to the valve stem by means of three cross-arms. The cross-arms are guided in their vertical movement by rollers and slides running in adjustable grooved tracks securely fastened in the concrete. To reduce friction, trains of rollers are provided connecting with vertical sheaves which are raised and lowered by a cable, the upper end of which is fastened to a shock absorber on the top of the wall; the other end after passing through the sheave is rigidly fastened to the moving valve. By this arrangement the travel of the roller train is one-half that of the valve. From experiment at Panama with a similar apparatus it was determined that the coefficient of friction was .0226. To this must be added the friction of the valve due to the side water seals.

The valve has been designed with a view of providing sufficient metal to allow for corrosion and also to withstand, in addition to computed stresses, water-hammer or carelessness of operation. It is not possible to determine the maximum effect of water-hammer should the valve be accidently closed rapidly while the water in the culvert is moving at its maximum rapidity. However, the valve is designed to withstand stresses due to hydrostatic head of 90 feet, which is 2½ times the actual maximum head. The beams have been increased from 55 to 93 per cent over the section required to withstand the determinate stresses. A throttling device has been added to stop the movement of the valve gradually, at its highest and lowest limits.

Using the coefficient of friction above mentioned, it is found that it will require a pull of about 10,000 pounds to overcome the rolling friction at the start of the motion. The friction of the side seals has been assumed at 1,700 pounds, making the total friction something under 12,000 pounds. The weight of the moving part of the valve is 44,000 pounds, requiring a pressure of 56,000 pounds to lift the valve at the beginning of its opening. This pressure decreases as the valve lifts and offers less surface against the pressure of the water in the culvert. The pipes and all apparatus containing the oil are designed to withstand a pressure of 1,500 pounds, but it is assumed that the working pressure will be 500 pounds. With this pressure the lifting power against the sliding cylinders will be 66,000 pounds, leaving a margin of 10,000 pounds to overcome any sticking of the valve and the inertia of starting movement.

The fixed plungers or pistons are to be 9¾ inches in diameter and the cylinders 10¼ inches internal diameter. This allows ¼ inch clearance all around the plungers, so that the interior surface of the cylinders need not be finished. A tight packing joint is provided at the bottom of the cylinders to prevent escape of oil. The stroke to open the valve for inspection is 16 feet 6 inches, and the approximate quantity of oil required is 95 gallons. The time for opening or closing the valve is assumed as one minute. The upper valves, being placed much higher than the lower ones, have to resist only about one-half the hydrostatic pressure on the latter. It is estimated that the two lower valves will cost $10,000 each, and the upper valves $7,000 each. This will include all the machinery, castings, etc., for the complete valve.


SECTION A-A
66'-4¾" Center to center of bearings
Outline of Foot Walk at Miter End & Cantilever
℄ of Miter & Locking Points
15×½" Pl
Flanges 1L 6×6×⅝ Web ½
10"[@15#
Rib 6×4
B
B
15'-10 3/16"
1½" Pipe Galvanized
Top of Foot Walk Elev. 423
Pin Casting of Miter forcing Machine Machine is on opposite leaf For general arrangement see Sheet
Tapered Girder 4L 6×6×⅝ Web 7/16
Vertical Girder Flanges 2L 6×6×¾ Web ⅜
Vertical Girder Flanges 2L 6×6×⅝ Web ½
Girder 4L 6×4×⅜ ⅜" Web
Gusset Pls ½" unless shown otherwise
Miter Guard here on opposite Gate Leaf
Miter Guard here for Detail see Sheet
A
A
DOWNSTREAM ELEVATION
7 Supports for Foot Walk Flanges 2L 3×3×⅜ Web ⅜
Foot Walk ¼ Checkered Pl
7, ⅜ Gusset Pls
Elev. 414.274
2L 6×6×⅝ Web ½
4L 3½×3½×⅜ Web 30×⅜
4L 6×6×⅝ Web 30×⅝
4L 6×6×1/2 Web 30×1/2
4L 6×6×11/16 Web 30×11/16
4L 6×6×¾ Web 30×¾
3L 6×6×¾ Web ⅝
16, ⅜ Fill. Pls
Diagonal not shown
1L 6×6×⅝
46'-7½"
3'-10⅝"
℄ Elev. 317.849
Elev. 372
Elev. 371.792
SECTION B-B

OHIO RIVER
LOCK AND DAM NO. 41.
LOWER GATE
GENERAL DRAWING
SCALE: ¼ In. = 1 Ft.

FIGURE 10

Oil will be used for the operation of these valves and the jacks used for opening and closing the gates. It is proposed to obtain electrical power from a commercial plant located adjacent to the canal. For the privilege of taking water from the canal for the circulating system of the big electric lighting and power plant now being constructed, the power company has agreed to furnish power to the United States for 1 cent per K. W. hour. This power will be used to operate electrically driven pumps, to fill accumulator tanks placed on the wall, and the pipe lines leading from these accumulator tanks to the valves and gate jacks will transmit pressure for actually operating the machinery. These accumulators are to be designed with sufficient capacity to furnish also the necessary oil under pressure for the operation of the gates of the old lock, thus enabling the abandonment of the present steam plants and capstans now in use.

LOWER GATE. (*Fig. 10.*)

The general conditions existing at the lock are as follows:

Width of lock, 110 feet.
Elevation, lower sill, 372.
Low water, Dam 42 down, 378.
Elevation, lower pool, Dam 42 up, 383.
Elevation, upper pool, 418.
Maximum lift, 40 feet.
Elevation, top of walls at gate, 423.
Height of gate, C. to C. of extreme horizontals, 46 feet 7½ inches.

The lower gate for this lock is larger than any mitering gate in use, except those at Panama and the one at Keokuk. It is about the same size as the upper gates at Panama but not as high as the lower gates, due to the greater depth of water on the sill, 45 feet as opposed to 11 feet. The lift, however, is much greater than that at Panama, being 40 feet as opposed to 28 2-3. The dimensions and conditions are almost identical with those found at the Keokuk lock.

A careful study of the largest gates previously designed was made, and tentative designs were prepared of two types; first, the ordinary horizontally framed gate, like those used at Panama, and second, a vertically framed gate.

With the former type each horizontal girder carries its share of the pressure to the side walls, acting as a combined girder and strut, while the pressure against the sill is sufficient only to prevent leakage. The maximum pressure is on the lowest girder, reducing successively at each girder to a minimum at the top. With the vertically framed type the whole pressure is carried by a top girder and the sill, the pressure being transmitted to them by vertical girders resting against the sill at the bottom and the main girder at the top. With no downstream pressure and lock full, the top girder would carry one-third and the sill two-thirds of the total pressure. This is the extreme case and these proportions will vary as the head on either side varies.

Theoretically, the vertically framed type seemed the better for our conditions, that design lending itself to greater economy in weight, simpler construction, greater accessibility for cleaning, painting, etc., and greater stiffness. The safety of a gate of this type depends, however, on maintaining a perfect miter of the upper girders, and on the stability of the sill under very heavy stress. With the horizontally framed gate an error in miter at the top decreases to zero at the sill. It will be seen, therefore, that the top girders might be driven out of miter by impact, yet the remaining girders be in sufficient contact to carry the pressure to the side walls, and consequently the gate would not fail. With a vertically framed gate, however, if the top girders are not in miter the whole gate fails, as the remainder of the gate can not transmit the thrust to the side walls. Furthermore, the stability of a vertically framed gate is entirely dependent on the stability of the sill and any doubt as to the character of the rock under the sill is a strong argument against its adoption in favor of a horizontally framed gate, which, if properly mitered, would remain in place even if the sill gave way. As excavation of the lock pit progressed, it was found that the rock is not as massive as was thought. It lies in horizontal strata with permeable seams and there is considerable danger of water getting under the sill to produce hydrostatic head or uplift.

For the above reasons and the additional one that no gate of this size of the vertically framed type has been built, the Chief of Engineers' Office was adverse to its adoption, and the design was abandoned. At about this time the Keokuk gate was completed and was found to admirably fulfil is function, being extremely stiff and in all ways very satisfactory. As the dimensions are almost the same as those of the gate we are to build we have adopted that design, adapting it to our conditions by very slight changes.

The Keokuk gate was described in the *Engineering Record* of July 26, 1913, and consists of horizontal circular arches supporting the skin, the girders being backed by heavy diagonal plate girders from corner to corner of the gate. Our design differs from that of the Keokuk gate as follows:

	No. 41.	Keokuk.
Height of gate	46 feet 7½ inches.	48 feet 0 inches.
Spaces C. C. of arch	12 at 3 feet 10⅝ inches.	12 at 4 feet 0 inches.
	No buoyancy chamber	Buoyancy chamber.
Operating device	Hydraulic jack	Bull wheel.
Miter forcing machine	Operated by hydraulic jack.	Operated by pneumatic jack.

Arrangements will be made for the use of a mitering machine on top of the gate similar to that used on the Keokuk and also on the Panama gates. It consists of a jaw on one leaf which seizes a post on the other leaf and draws the two leaves together. On the Panama gate this device is operated electrically, on the Keokuk gate it is operated pneumatically, and on our gate, if placed, it will be operated hydraulically, using oil under pressure.

Two sets of projecting cast steel arms will be attached to the miter post of each leaf and will act to prevent accidents in case of impact by moving boats. The possibility of this occurring from the upstream side is remote, yet it is possible and has occurred. In 1901 a steamer struck the north leaf of one of the gates of the Poe Lock at Sault Ste. Marie, from the upstream side and knocked the north leaf 3 or 4 feet beyond the south leaf of the miter post. (See Report of the Chief of Engineers, 1902, Part III, page 2225.) The presence of this protective device should greatly reduce the chances of an accident of this nature.

Most of the accidents to lock gates of which we have found reliable records are caused by boats hitting one leaf from below, pushing the leaf upstream enough to remove the support for the other leaf, thereby allowing the other leaf to swing downstream and tear loose from its anchorage. Of nine accidents to lock gates investigated, six were from impact below and three from above. The projecting arms will be of great service in protecting the gate from destruction from this cause. Provided the blow has not force enough to push one leaf entirely beyond the end of the arms on the opposing leaf, the water pressure will bring the two leaves together again.

UPPER GATE.

(*Fig. 11.*)

The present normal depth of water on the upper sill is 11 feet, which will be increased to 17 feet after the new dam is in operation. The upper gates will be used on a rising river until the depth is approximately 20 feet, when the guard gates will be closed and the lower pool will have risen to within a few feet of the upper pool level. To allow for all possible contingencies the skin of the gate is carried to height of 22½ feet, and to provide a foot walk on top of the gate, level with the top of the wall, the frame of the gate will be 24 feet 8 inches high.

The width of the lock is 110 feet and the length of each leaf will be approximately 63 feet. The ratio of height to length is therefore 39-100. So far as known to this office, no mitering gate of such small ratio of height to length has been built, the nearest approach being the guard gate at Sault Ste. Marie, the height being 27 feet and length 56½, the ratio being approximately 48-100.

In the general case where the ratio of height to length is as small as this, the rolling gate or a vertical lift gate would probably be selected. Owing to the large amount of silt carried by the flood waters and the difficulty of cleaning out the recesses at those locks where the rolling gate is now used on this river, this type was rejected. Other peculiar conditions prevented the adoption of a vertical lift or movable dam type and after a careful study the mitering gate was adopted as the best for this site.

In the design, special efforts were made to make the gate stiff against warping and sagging. The most effective way of accomplishing this seemed to be by heavy adjustable diagonal braces. It was soon found that the ordinary horizontally framed type, of the required dimensions, did not lend itself readily to being braced properly to withstand warping and sagging, and that the vertically framed gate did so lend itself. Consequently this latter type of gate was finally adopted.

This type has numerous advantages over the horizontally framed gate for the size and shape considered. It is more readily inspected, cleaned, and repaired than the other type; has no large horizontal girders which would collect silt and divide the gate into a number of compartments difficult of access for cleaning and painting; the skin can be more readily placed to keep the total upward pressure less than the weight of the gate. Examination

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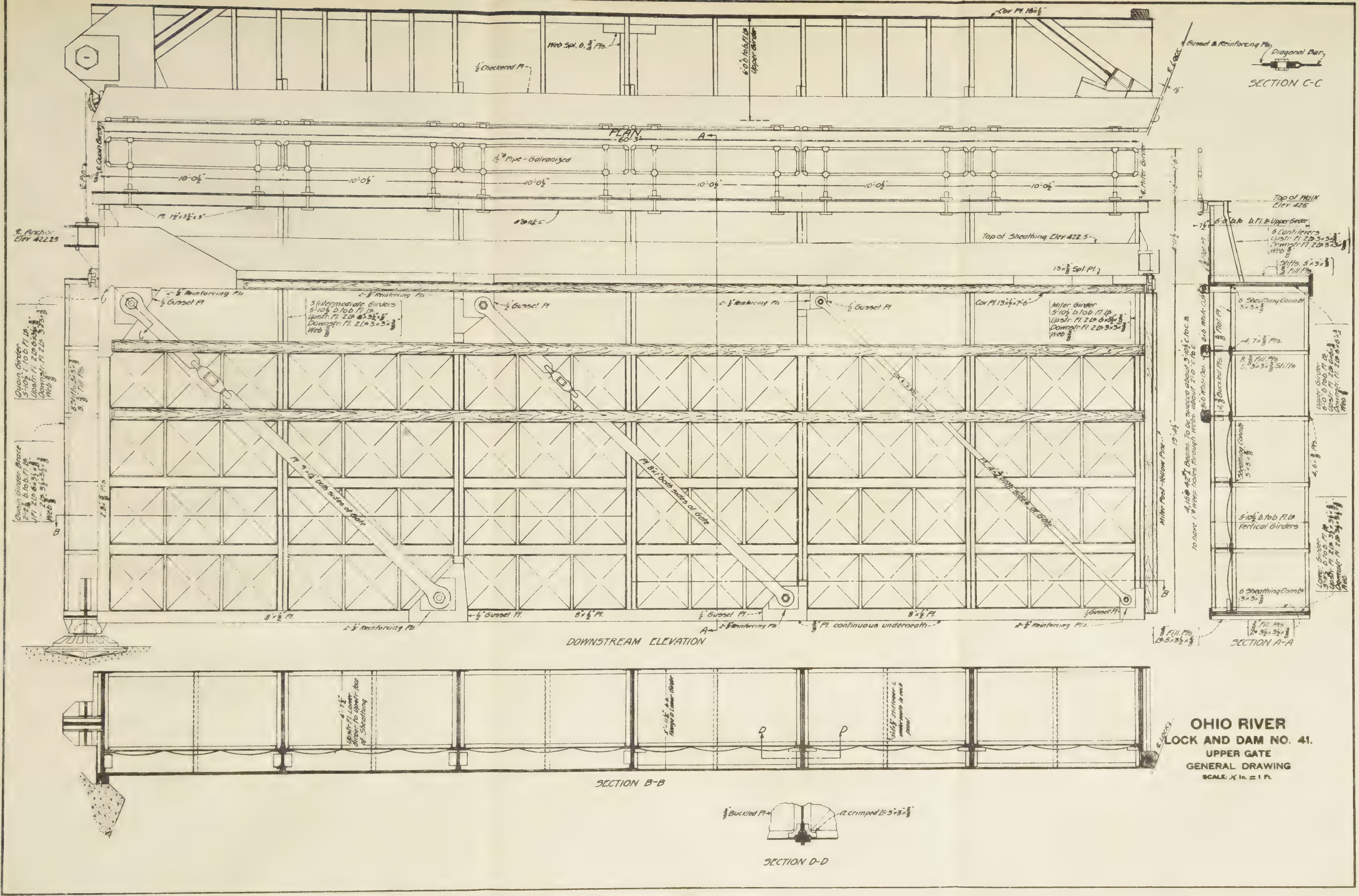

PLAN
60'-3"
Cor. Pl. 18 x 1/2
Web Spl. 6, 3/4" Pls.
1/2" Checkered Pl.
6'-0" b. to b. Fl. Ls Upper Girder
Gusset & Reinforcing Pls.
Diagonal Bar
SECTION C-C
1 1/2" Pipe - Galvanized
10'-0 1/2"
℄ Anchor Elev. 422.25
Top of Walk Elev. 425
Top of Sheathing Elev. 422.5
13 x 3/8 Spl. Pl.
2-3/8 Reinforcing Pls.
1/2 Gusset Pl.
5 Intermediate Girders
Cor. Pl. 13 x 1/2 x 7'-6"
Miter Girder
Quoin Girder
Quoin Girder Brace
Pl. 9 x 1 1/2 both sides of Gate
Pl. 8 x 1 both sides of Gate
Pl. 4 x 3/4 both sides of Gate
Miter Post - Yellow Pine
19'-4 1/2"
6 Sheathing Conns.
4.7 x 3/8 Pls.
3/8 Buckled Pl.
Sheathing Conns.
5-10 1/2 b. to b. Fl. Ls Vertical Girders
Upper Girder
Lower Girder
8 x 1/2 Pl.
1/2 Gusset Pl.
2-3/8 Reinforcing Pls.
3/8 Pl. continuous underneath
DOWNSTREAM ELEVATION
SECTION A-A
SECTION B-B
3/8 Buckled Pl.
12 crimped Ls 3 x 3 x 3/8
SECTION D-D
A
B
C
D

OHIO RIVER
LOCK AND DAM NO. 41.
UPPER GATE
GENERAL DRAWING
SCALE: 1/8 In. = 1 Ft.

FIGURE 11

also shows that the vertical type is less expensive than the horizontal type where the ratio of height to length is small, if equal stiffness is obtained. The principal objection to this type of gate is that the whole pressure against the gate is carried by the sill and the upper girders. The girders must have ample strength to carry their load as beams, and also be able to transmit the resulting thrust to the walls. This requires that the miter of the upper girders be perfect, else the whole gate fails.

With no water on the downstream side of the gate, the sill must resist the overturning and sliding effect due to two-thirds of the total pressure transmitted directly to the sill by the vertical members. This requires a heavy sill capable of resisting great forces. In this case the material in which the pit is being excavated is such that a heavy concrete head-wall must be carried to the bottom of the pit to cut off flow from the forebay through the rock strata, and this head wall will be arched into the side walls and will form part of the sill. We shall, therefore, be sure of a substantial sill, capable of carrying the pressure transmitted to it by the vertical members.

This gate, as designed, is in effect two Pratt trusses separated 6 feet by vertical girders, and the whole hung from one end as a cantilever. The skin is between the trusses and near the downstream side of the gate.

General Conditions and Assumptions.

Width of lock	110 feet.
Elevation of top of sheathing	422.5
No lower pool acting on gate.	
Elevation of top of sill	401.0
Maximum head on gate	21.5 feet.
Assumed weight of one leaf for calculation of stresses in anchorage and diagonals	120,000 pounds.
Type of gate	Mitering, vertical frames, single sheathing.
Miter angle (tan. $^{-1}$ 0.4)	21° 48′ 05″.
Length of each leaf C. to C. end verticals	60 feet 3 inches.
Length of each leaf over all, about	63 feet 6 inches.
Height of gate C to C. of upper and lower horizontals	19 feet 4½ inches.
Height of gate over all without hand rail	24 feet 8 inches.
Width of gate, B. to B. of flange angles, upper girder	6 feet 0 inches.
Width of gate over all	6 feet 7½ inches.
Approximate weight of one leaf	130,000 pounds.

Each leaf consists of the sheathing plates and framework supporting same. The sheathing is supported by four horizontal stringers, which are in turn supported by vertical girders. The vertical girders carry the loads from the stringers and sheathing to the sill and upper horizontal girder. The upper horizontal girders of the two leaves bear against each other on the center line of the lock and against the lock walls through suitable reaction castings. The gate, as a whole, is supported as a cantilever truss, with adjustable diagonal tension bars. The sheathing is of buckled plates in strips equal in length to the distance between vertical girders, and is 3/8 of an inch thick throughout. It is supported by horizontal stringers of 15-inch I-beams, 42 pounds per foot. The vertical girders are built-up plate girders, and are made deeper than necessary in order to separate the Pratt trusses a sufficient distance to make the gate a very stiff structure.

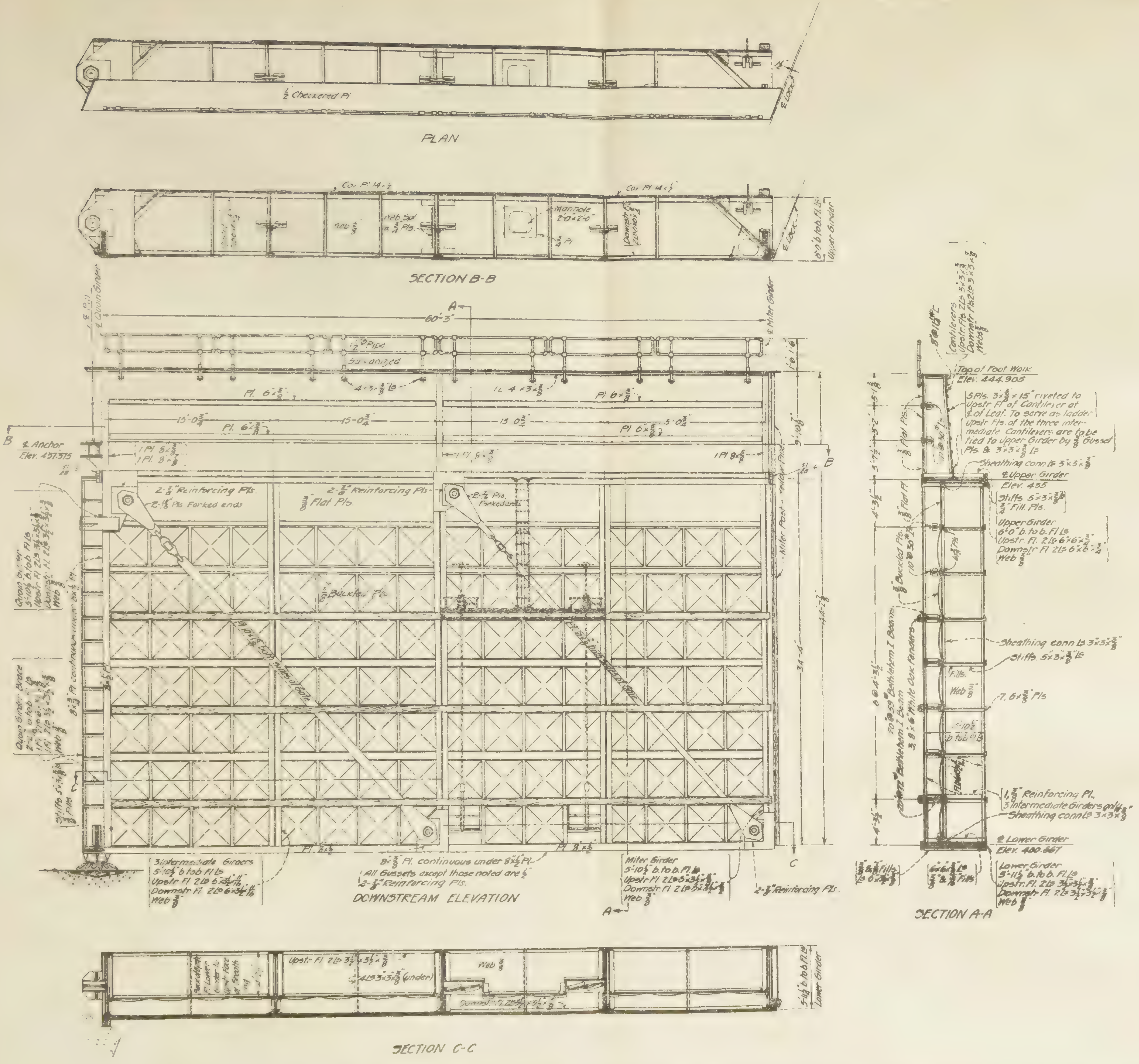
The upper girder is the only part of the gate that carries thrust to the walls and is made exceedingly heavy. The position of the line of thrust is confined within narrow limits by the shape of the end castings, and no allowance is made for variation of its position, except by the use of the low unit stresses and the assumption of a very severe condition of pressure on the gate.

This girder is located below the level of the walls, and the additional height is given to the gate by building above the top girder to the elevation of the top of the wall by cantilevers which support the footwalk. By this means a lighter structure is obtained, the point of application of the thrust against the wall is lowered, and the gate operating jack can be placed under covers below the top surface of the walls.

A miter forcing machine similar to that described for the lower gate is to be used, and will be attached to the upper horizontal girder. The projecting arms which are to be used on the lower gate are not to be used on the upper gate, because the gates are protected from impact from the downstream side by the miter wall.

The sill is of structural steel shapes anchored to the concrete foundation. The inclined anchor rods are set in pipes and an initial tension given them in order to prevent displacement of the sill due to the stretching of the rods when the pressure acts against it.

One of the difficult minor problems in the design of a vertical frame gate is the arrangement of the contact between the two



PLAN
½" Checkered Pl.
SECTION B-B
Cor. Pl. 14 × ½
Manhole 2'-0" × 2'-0"
6'-0" b. to b. Fl. Ls Upper Girder
℄ Lock
A
60'-3"
1½" Pipe
Galvanized
Pl. 6 × ⅜
15'-0¾"
1 Pl. 8 × ⅜
B
℄ Anchor Elev. 437.375
2-½" Reinforcing Pls.
2-1⅛" Pls. Forked ends
⅜" Flat Pls.
½" Buckled Pls.
Miter Post - Yellow Pine
℄ Miter Girder
Quoin Girder
Quoin Girder Brace
34'-4"
3 Intermediate Girders 5'-10½" b. to b. Fl. Ls Upstr. Fl. 2 Ls 6 × 3½ Dowmstr. Fl. 2 Ls 6 × 3½ Web ⅜
8 × ⅜ Pl. continuous under 8 × ½ Pl.
All Gussets except those noted are ½
2-½" Reinforcing Pls.
DOWNSTREAM ELEVATION
Miter Girder 5'-10½" b. to b. Fl. Ls Upstr. Fl. 2 Ls 6 × 3½ Dowmstr. Fl. 2 Ls 6 × 3½ Web ⅜
2-⅝" Reinforcing Pls.
A
C
Top of Foot Walk Elev. 444.905
5 Pls. 3½ × ⅜ × 15" riveted to Upstr. Fl. of Cantilever at ℄ of Leaf. To serve as ladder. Upstr. Fls. of the three intermediate Cantilevers are to be tied to Upper Girder by ⅜ Gusset Pls. & 3 × 3 × ⅜ Ls
Sheathing conn. Ls 3 × 3 × ⅜
℄ Upper Girder Elev. 435
Upper Girder 6'-0" b. to b. Fl. Ls Upstr. Fl. 2 Ls 6 × 6 × ⅜ Dowmstr. Fl. 2 Ls 6 × 6 × ¾ Web ⅜
Sheathing conn. Ls 3 × 3 × ⅜
Stiffs. 5 × 3 × ⅜ Ls
Web ⅜
1, ⅜" Reinforcing Pl. 3 Intermediate Girders only
Sheathing conn. Ls 3 × 3 × ⅜
℄ Lower Girder Elev. 400.667
Lower Girder 5'-11½" b. to b. Fl. Ls Upstr. Fl. 2 Ls 3½ × 3½ × ⅜ Dowmstr. Fl. 2 Ls 3½ × 3½ × ⅜ Web ⅜
SECTION A-A
Upstr. Fl. 2 Ls 3½ × 3½ × ⅜
Web ⅜
5'-11½" b. to b. Fl. Ls Lower Girder
SECTION C-C

OHIO RIVER
LOCK AND DAM NO. 41.
GUARD GATE
GENERAL DRAWING
SCALE: ¼ In. = 1 Ft.

FIGURE 12

leaves and between the gate and the wall to prevent leakage and in such a manner as to prevent any thrust being transmitted through the gate except through the top girder. The problem is solved at the quoin by using a wooden strip on the side of the gate which is brought into contact with the hollow quoin when the gate is closed. At the miter, wooden posts are to be used, adjusted so that no thrust will be transmitted through the gate.

The gate rests on a hemispherical pintle and is held at the top by a yoke with arms set into the concrete and connected with substantial anchorage grillage, to distribute the forces of tension and compression through the mass concrete.

To take care of the sagging and warping which would be pronounced in a gate of these dimensions, diagonal brace straps with turnbuckles will be used. These straps are proportioned as the diagonals of a cantilever pin-connected truss, and the unit stress used is only one-half of that permitted in other parts of the gate. This is to take care of non-computable stresses that result from pulling the gate through water or through mud in opening and closing it.

GUARD GATE.

(*Fig. 12.*)

While the present normal pool is at elevation 412 and the proposed new pool will be at elevation 418, during extreme floods the upper pool rises to elevation 449.7, and the lower pool rises more rapidly than the upper pool, so that by the time the upper pool is at elevation 420 the difference is not more than 2 or 3 feet, and this difference is reduced until at the extreme flood elevation there is a fall of a foot or less. Guard gates are provided whose sill has the same elevation as the sill of the upper gates with top of gates at elevation 444.9, which is higher than the greatest height of flood waters, except those of 1884 and 1913. These guard gates will be used simply to prevent a flow of water through the locks on a rising river when the upper pool becomes higher than the top of the upper gates. At no time is there a great difference of head against these guard gates, the head varying from 3 to 4 feet to 1 foot or less, depending upon the time when the gates are closed and the height of the flood.

These guard gates, however, may be used as a coffer to enable repairs to be made to the upper gates or for investigation of and repairs to the valves. For this reason, therefore, they must be made strong enough to withstand a head of approximately 20 feet on the upstream side with no head on the lower side of the gate.

It will be seen, therefore, that each leaf of this gate must be approximately 45 feet high by 63 feet long, must be strong enough to resist a head of approximately 20 feet on the lower part of gate and a difference of head of only 3 or 4 feet above elevation 422.5. The gate will be used very seldom and for purposes which will allow time and care in the operation. The greatest difficulty will be to prevent sagging, due to its own weight, and warping when operated without making the gate unnecessarily heavy.

The conditions, therefore, indicate very strongly the use of a vertically framed gate, and one of this type has been designed and approved by the Ohio River Board. It resembles very closely the proposed upper gate. It has two butterfly valves set in the gate, to be used for purposes of equalizing the pressure on both sides after flood waters have subsided, or when used as a coffer, for filling the space between upper and guard gates.

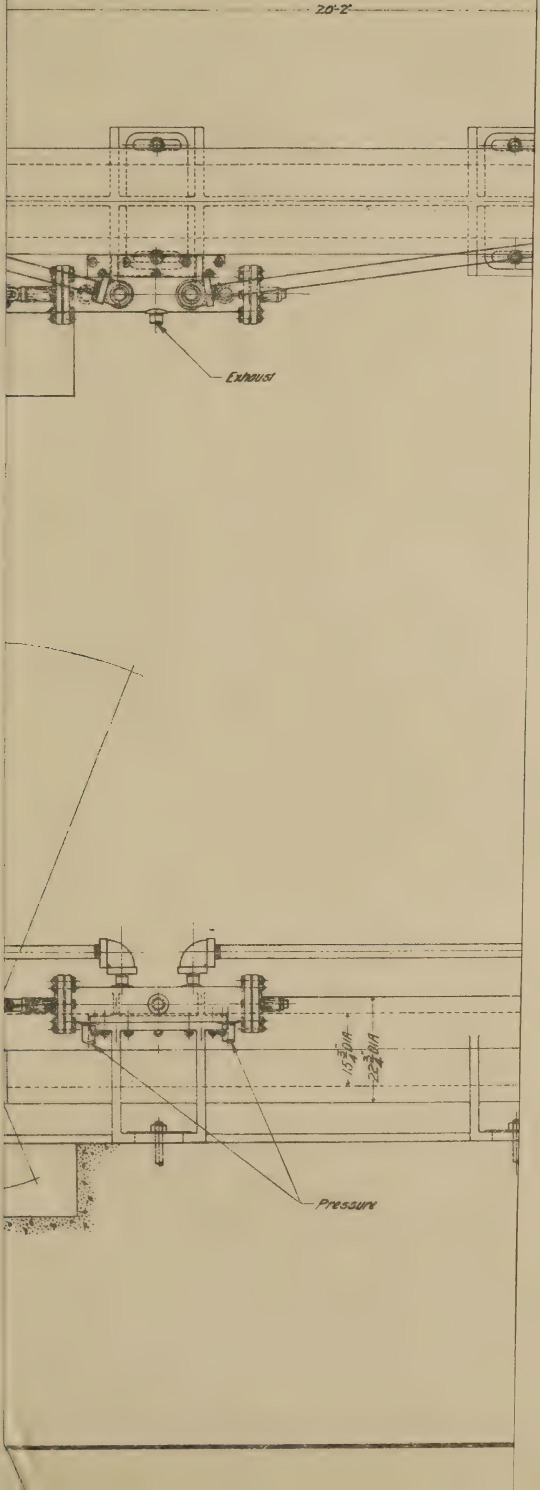
As the guard gates will be operated at infrequent intervals and there will be ample time for operation, no operating mechanism is provided; the gates will be opened and closed by wire ropes about capstans on the walls.

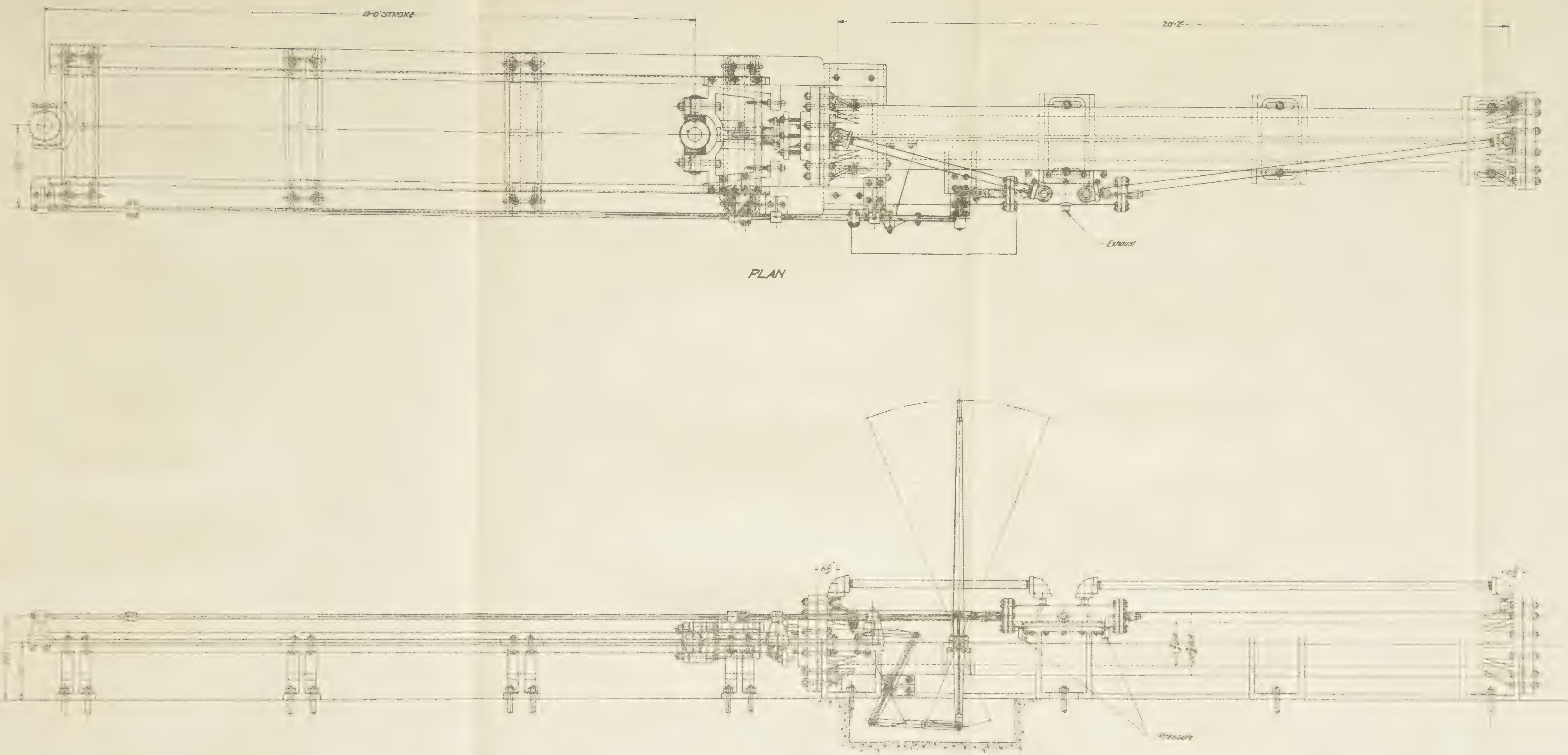
JACKS FOR OPERATING GATES.

(*Fig. 13.*)

Each gate will be opened and closed by the direct action of a piston connected to the gate and working in cast iron cylinders, using oil under pressure as the motive force. The cylinders will be 3½ inches thick, with inside diameter 15.75 inches. The approximate weight of each cylinder is 18,000 pounds. Oil will be admitted through pipes connected to the ends of the cylinder; while one of these pipes acts as a supply pipe, the other acts as the exhaust or return pipe.

The piston packing rings are made of cup leather washers placed between heavy concentric disks and separator rings clamped together at the end of the piston rod. The piston valve is designed to be as nearly balanced as possible, and aside from friction should move easily by a system of levers and a link motion connected to the cross-head by a sliding rod. A throttling device is attached so as to reduce the flow automatically near the end of the stroke. The starting mechanism consists of a hand lever projecting above the wall. This lever will be provided with a suitable locking device so that it can not be operated without a key. The piston is connected to the gate by a strut built up of structural shapes and provided with a suitable spring buffer.


20'-2"
Exhaust
15¾" DIA
22¾" DIA
Pressure


12'-0" STROKE
20'-2"
Exhaust
PLAN
Pressure

OHIO RIVER
LOCK AND DAM NO. 4
LOCK
GATE JACK.
PLAN AND ELEVATION.
SCALE: ¼ In. = 1 Ft.

FIGURE 13

OIL PRESSURE PUMPING PLANT.

The pumping plant for operating the Stoney gate valves and the gate jacks will be composed of two identical units properly cross-connected, each having sufficient capacity to operate the entire system. Each unit will consist of one dead-weight accumulator and one single-acting, triplex, or double-acting duplex power pump, with 500 pounds minimum gage pressure. The pump will be gear-driven by a 3-phase, 25-cycle, 550-volt, A. C. motor, with automatic control. This control will be arranged to stop the motor when the accumulator is fully charged and start it when the accumulator piston has descended one-tenth of its stroke.

The oil will be pumped to the jacks and Stoney valves under pressure of 500 pounds per square inch, and all piping, machines, etc., will be designed and tested for 1,500 pounds per square inch, giving a factor of safety of 3.

ELECTRIC LOCOMOTIVE.

At the present locks the barges are hauled into and out of the locks by means of steam capstans. At the new lock there will be no steam plant; as any capstans that might be used would be under water during flood it is practically impossible to use electric motors without having to remove them during each high water. Therefore it has been decided that on this lock an electric towing locomotive will be used, and the Jeffrey mine locomotive, weighing 25 tons, has been adopted as the type to be furnished.

The general plans for the work were determined under the supervision of my predecessor as district officer, Maj. Lytle Brown, Corps of Engineers. The changes, design of valves, gates, gate-operating mechanism, etc., described above, have been prepared during my incumbency. Very valuable assistance was rendered by Capt. John J. Kingman, Corps of Engineers, particularly with reference to selection and arrangement of the electric pumping machinery, traction locomotive, tracks, arrangement of and selection of bridges, etc.; Assistant Engineer W. H. McAlpine, Principal Assistant, who has had general charge of the work, checked all plans and designs and suggested many practical details with reference to gates, valves and methods; Junior Engineer Malcolm Elliott, chief designer and draughtsman, who made all computations and designs for the gates; Junior Mechanical Engineer Paul Grunwell, who designed the Stoney gate valves and hydraulic jacks, and Junior Engineer W. I. Gregory, who designed the emergency dam for the canal.

Development of Explosive for Our Demolition Equipment

BY

Maj. W. G. Caples
Corps of Engineers

For a good many years past we have been using one explosive or another for demolition purposes, but none of those explosives used has been really suitable for the purpose. The reason for this was that suitable explosives in suitable form were not to be had on the American market. We could import explosives of the kind required but in so doing we should make also a basic error in military policy, because, in case of war, the source of supply might be cut off.

When the E. I. Du Pont de Nemours Powder Co. began the manufacture of trinitrotoluol for sub-marine mines and for shell filler it appeared that possibly this explosive might answer our requirements. Two forms of the explosive were obtainable: the crystals put up in paper-covered sticks like dynamite, and castings of almost any desired size or form. Experiments were begun about 1910 to see what could be done with these forms of the explosive. It was found that the castings were too insensitive to be detonated by any primer which it was considered safe to carry. The crystals could be detonated with the ordinary No. 6 blasting cap, which contains one gram of fulminate-chlorate mixture all compressed.

In the crystalline form, trinitrotoluol is very lacking in density, which makes the cutting effect somewhat low although probably as great as that of rack-a-rock or of a 40 per cent dynamite. When thoroughly wet, the crystals are insensitive to the action of even a 2-gram primer, but the explosive absorbs water very slowly. It was found that a stick could be left under water for eight or ten hours and still be detonated. After experimenting with the explosive for somewhat over two years it was decided to adopt trinitrotoluol in the crystalline form for issue to engineer troops.

Investigation of foreign markets brought out the fact that trinitrotoluol is now practically the universal explosive for demolition purposes. Advantage is taken of the fact that under very high pressures the crystals can be made to adhere and formed into blocks of even higher density than the castings of the same explosive. The sensitiveness of the explosive falls off very rapidly with the compression, but not to such an extent as when the explosive is melted and cast. The density used abroad is about 1.6. At this density the explosive is so insensitive as to be beyond the reach of even a 2-gram fulminate-chlorate primer. This difficulty is obviated by the use of primers of lead azide ($Pb\ N_6$), which is said to have about ten times the detonating effect of mercury fulminate. The blocks of the compressed explosive are quite friable, the friability increasing with the density. To obviate this difficulty, the blocks are copper-plated. The plating adds about 50 grams weight for each kilogram of the explosive. Complete outfits of this kind can be obtained at a price which would make the explosive cost approximately 60 cents per pound, delivered duty free in the United States.

The amount of business involved in demolition equipment for our army is so small that the manufacturers decline to make any attempt to furnish the explosive and primers in a form equal to those which could be imported. After some correspondence and conversation on the subject, arrangements were made with the E. I. Du Pont de Nemours Powder Co. to undertake at Government expense the compression of trinitrotoluol into blocks of suitable form for demolition purposes.

The E. I. Du Pont de Nemours Powder Co. stated that it was experimenting with the lead azide primer, but was not prepared to furnish it. The first experiments undertaken were, therefore, to determine the maximum density at which trinitrotoluol can be certainly detonated by the commercial 2-gram primer, which is the heaviest to be found on the American market as a standard article. After some 249 tests were made, it was determined that 1.48 is about the limiting density. At a density of 1.501 the failures amounted to 7 per cent, while at a density of 1.588 the failures amounted to 70 per cent. Below 1.5 there were no failures. On account of the somewhat crude equipment for compression, there is a variation of about 0.02 in the density of the blocks. The specifications therefore were made to call for a density of between 1.44 and 1.48. The average density of blocks furnished is 1.468, obtained by a pressure of approximately 10,000 pounds per square inch.

It was found in these experiments that blocks longer than 4 inches in the direction of motion of the piston of the press could not be successfully made, as planes of weakness were developed in the blocks and the compression was irregular. An attempt was made to remedy this defect by the compression of one charge on top of another, but it was found that an even more decided plane of weakness was developed in this manner. With the size of the press used, the cross section of the block perpendicular to the direction of the motion of the piston could not be greater than about 4 by 4 inches. These considerations limited experiments to a block which could be taken from a 4-inch cube.

The next work done was to determine a suitable form of block. In demolition work, any air gap between the explosive and the substance to be cut has a very material effect. For metal, masonry, and other substances having approximately plane surfaces, a cylinder is markedly less efficient than a rectangular prism of the same weight. For work in bored holes, the conditions are exactly reversed. It was decided, therefore, to furnish both blocks (rectangular prisms) and sticks (cylinders). It was decided that a convenient form of block would be one which, when tamped in the web of the heaviest rail used, would certainly cut the rail out between ties. A rough computation indicated that a cross section of about 1¾ by 1¾ inches would be suitable for this purpose. The length was left open to be determined by experiments. As the result of experiments, it was found that 3 inches would give a sufficient length. As the blocks of this length and the cross section used weighed very nearly ½ pound, it was decided, for convenience in computing charges, to make the blocks weigh exactly ½ pound each. The resulting form of block is 1¾ by 1¾ by 3 3-16 inches, with a cap-hole bored in the direction of its longest axis. The edges of the block are rounded and a coating of paraffin is given to decrease the liability of the block to break up when dropped or struck. A block of this size *tamped* in the web of a 90-pound rail will certainly cut the rail out between two ties and generally between four ties. The experiments indicated that the size of block developed is somewhat wasteful and probably that a cross section 1 by 1¾ inches would serve as well but, on account of the fact that funds for experimental work were practically exhausted, no other size of block was tried. The diameter of the stick is limited by the size of auger which is practical to carry and to use. The limiting diameter was considered to be 1½ inches for the

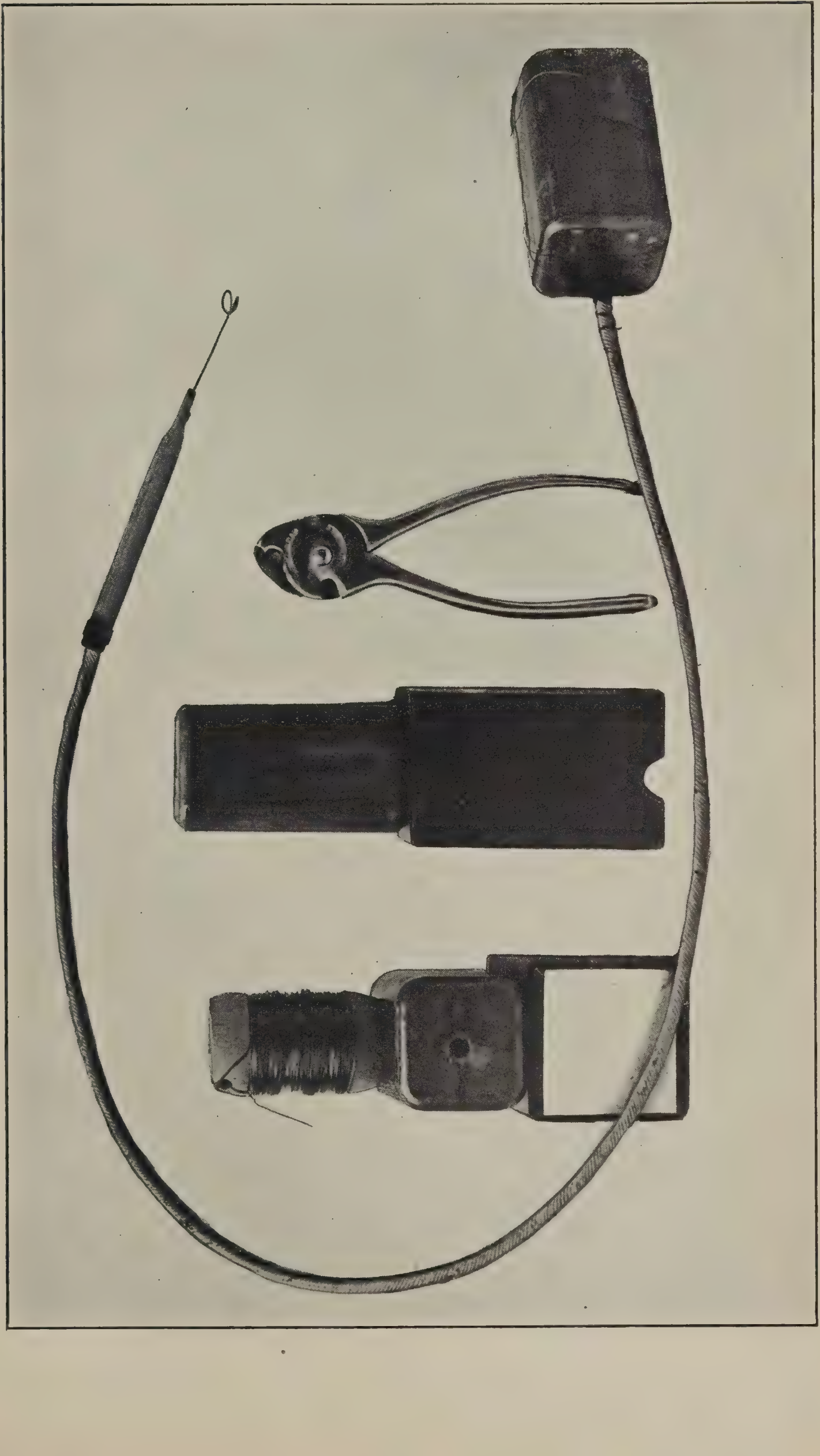


Fig. 1. End and side views of trinitrotoluol blocks and pasteboard containers, copper wire, crimper, and primed block with cap wired in and fuse lighter attached with wire drawn out ready to fire.

auger. As 1/4-inch clearness must be allowed, the diameter of the stick was fixed at 1 1/4 inches. The most economical form of packing for the blocks is end to end in the pack box. As the sticks have to be packed in practically the same manner, the length of the sticks was limited to that of the blocks, namely 3 3-16 inches. Sticks of this size will weigh a trifle under 0.2 pound. The cutting radius may be taken at, roughly, 5 inches in hard wood and more in soft wood.

The block and stick have been given only a limited amount of test—not sufficient as yet to develop formulæ for their use. It is, however, safe to say that, *if the charges are tamped,* the formulæ for 50 per cent dynamite given in our Engineer Field Manual and the formulæ for wet gun cotton given in the English Manual of Field Engineering, both give charges which are amply large. The formulæ in the German Pioneer Manual are for the same explosive at a density of 1.6 and probably give charges which are a trifle small. Roughly, a block will cut its own length and 1 1/2 inches thickness of steel plate, 12 inches thickness of reinforced concrete, and 18 inches thickness of ordinary masonry. A stick will destroy any timber 10 inches diameter or square if tamped in a central hole. By following these rules, charges amply large can be very quickly computed without the aid of a handbook.

The packing of the rather friable explosive was a matter of some difficulty. Without further experimental work—for which no funds were available—the E. I. Du Pont de Nemours Powder Co. declined to offer copper-plated compressed blocks at less than $2.00 a pound, which was quite out of the question. It was therefore decided to furnish each block or stick in an individual telescopic paper box made of hard glazed paper. This packing is fairly waterproof and will be given a thorough service test before any further attempt is made to supply metallic packing.

The primer became a matter of considerably more concern than was originally expected. The first experiments were all made with the 2-gram blasting cap, which has the entire charge compressed. When tests were made of the corresponding electric primer, which has about one-tenth of its charge uncompressed about the bridge, some failures were noted. The Du Pont Powder Co. reported further that a block bored to receive an electric primer was liable to failure with the blasting cap, because of looseness in fit. I have not been able to verify this conclusion. Out of about fifty tests made, perfect detonation was secured in every

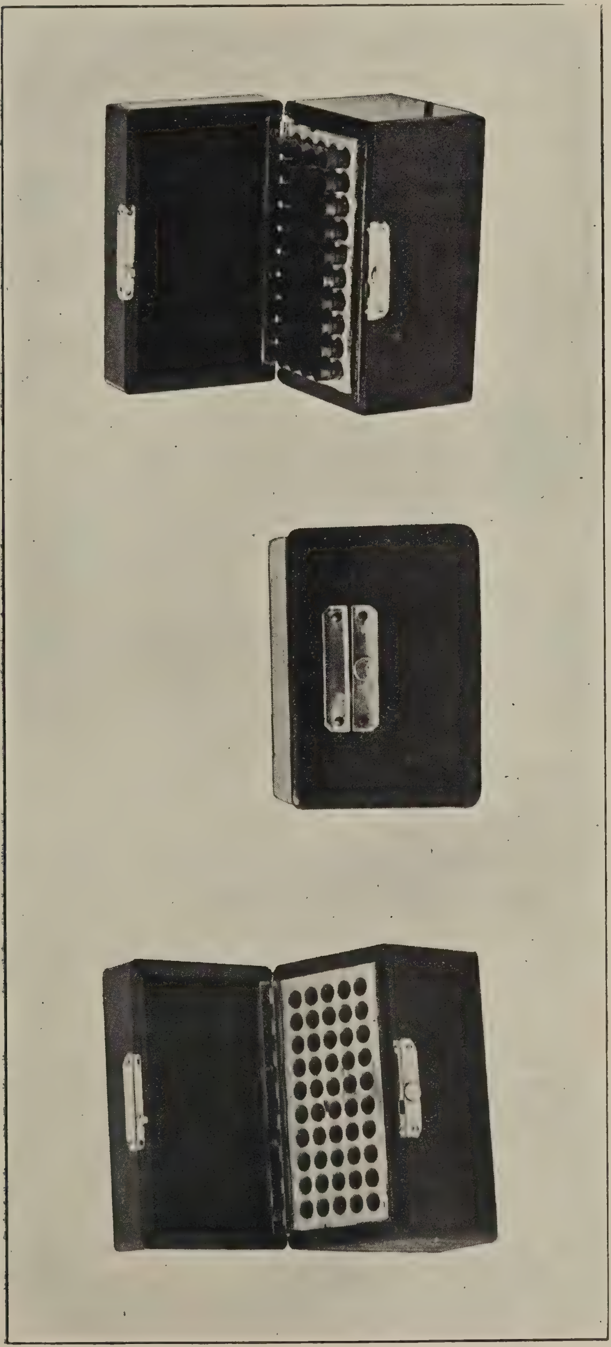


Fig. 2. Cap Boxes: Open, closed, and filled.

instance by the No. 8 blasting cap and, out of ten tests, perfect detonation was secured in each case with No. 7 cap. It was considered best, however, to keep on the safe side in this matter. Accordingly, it was decided to have the cap and electric primer both furnished in the same size shell. After consulting with the cap department of the Du Pont Powder Co., it was decided to use a copper shell 2 11-32 inches long .273-inch external diameter and .259-inch internal diameter for both caps and primers. The specifications for the contents of the primer were left open, the only requirements being that under test the primers and caps should detonate the blocks of explosive, and that with the caps there should be at least ¾-inch clear space for crimping. The caps as now furnished have a booster charge of 0.75 of a gram of trinitrotoluol. The composition of the detonator is unknown, but from its weight and effect it appears to be lead azide, as the last caps received contained only 0.5 of a gram of detonator and that amount of mercury fulminate, even with the booster used, would probably not detonate the blocks. Ten grams of crystalline trinitrotoluol detonated in contact with one of the blocks did not cause the latter to detonate.

In the carrying of these very powerful caps extraordinary precaution has been taken. Cap boxes of hard maple are to be provided. The lower part of each box is a solid block with a separate hole bored for each cap. The caps run somewhat irregular in diameter, requiring an allowance of about .018 inch in diameter of cap holes. The length of the caps, however, is quite uniform, making it possible to place in the bottom of each cap-hole and in the lid of the box 1-16 inch of felt, and to make the distance between the two felt surfaces exactly 2 11-32 inches. The box is provided with a piano hinge and a spring catch. The result is that each cap is held firmly but gently in place by the felt surfaces, which permit no motion of the cap whatsoever. The walls of the box give from ¼ to ½ inch of hard wood between any cap and the exterior of the box. The efficiency of the box has been tested by filling it with caps and throwing it from a height of 25 feet onto concrete with no worse results than to dent the wood.

One point that will certainly bring criticism in the new equipment is the fact that the cap-box is carried in the same pack box with the explosive. As a matter of fact, for the past ten years we have been carrying caps in the same box with much more sensitive explosives and taking little or no precaution on that account. An examination of the pack boxes actually in use showed that the caps were generally carried in a tin can—intended for matches—where they could roll around freely and then were placed in the boxes with no intervening partition between them and the explosive. To be sure, practice of this kind is merely an open invitation to disaster; that none has occurred is more good luck than good management.

Tests of the new explosive and primers showed in every case that a single layer of pasteboard between the cap and the block would prevent detonation. The Du Ponts reported that a film of paraffin in the cap hole prevented detonation in some cases. In nearly every instance, a cap inserted only half way into the cap hole failed to secure detonation of the block. To get a more conclusive test, a box was built of ¼-inch pine and divided into two compartments by a ¼-inch partition. In one compartment was placed a can containing 100 1½-inch gram caps; in the other compartment were packed four sticks of crystalline trinitrotoluol. The crystalline explosive is fully twice as sensitive as the compressed blocks. A lid was put on the box and the caps were detonated. Three of the sticks of explosive were recovered badly scorched and with one end blown off. The fourth stick was recovered badly scorched but otherwise intact. All were full of bits of copper from the caps. The ground about was covered with loose trinitrotoluol. The smoke of the explosion was of a clear bluish-white color without the slightest trace of the characteristic heavy black smoke produced by the detonation of trintrotoluol. In the remains of each stick a 1-gram primer was placed and perfect detonation secured thereby.

It is never safe to make a positive statement in regard to the action of explosives, because a very slight variation in conditions often has a marked effect upon the action of the explosive. It may possibly be true that the explosion of all the caps in the pack box would set off the explosive contained therein but, as at least ⅞ inch of wood intervenes between the caps and any of the explosive, the probability of such action appears to be too remote to warrant consideration.

The Ensign-Bickford Co. has recently put on the American market a detonating cord (*cordeau detonant*). This cord consists of a lead tube filled with crystalline trinitrotoluol. For all ordinary explosives it acts as a sufficient primer, but for extremely insensitive blocks of compressed trinitrotoluol it is useful only as a substitute for instantaneous fuse, which is not manufactured in this country and has to be imported from England. As the cord itself is of the same explosive as that contained in the blocks, two charges connected thereby amount to but a single continuous charge. The cord itself when split and inserted in a block of explosive is generally detonated by the explosion of the latter, but there have been some failures and, for safety in connecting up two charges, it is best to cap both ends of the cord and lead it between the two charges, inserting the caps *fully* into blocks of the two charges. The detonation of either charge will then detonate the other. As the rate of detonation of the cord is about 5,400 meters per second, there is no danger that the explosion of one charge will jar loose another charge on the same piece. Very remarkable cutting effects may be obtained in large charges by leading two pieces of detonating cord to opposite sides of the charge and then starting a detonation in the two pieces of cord simultaneously. The only precaution that has to be taken in the handling of the detonating cord is to see that the end is cut square and smooth before inserting it in a cap and after the cap is crimped on to hold on to the cap—*not the cord*—when inserting the cap in a block. The reason for this is that the metallic wrapper of the cord may set off the charge in the cap if pressed against it too hard or if it is left sharp when it is inserted in the cap. After a number of tests of the cord it was decided to use it in place of the electrical equipment in our packs. When the new order for engineer packs is printed, it will be noted that 20 pounds of detonating cord replace 65 pounds of electric firing apparatus and that the saving of 45 pounds has been taken off of the back of the mule, which previously was overloaded by fully that amount.

As the result of a number of tests made with the new equipment the explosive appears to be very nearly ideal, exploding when wanted and not exploding unless wanted. The only fly in the ointment will be found when an attempt is made to set charges under water. If the water gets into the cap hole and saturates the explosive about the cap there will be no detonation. A slight amount of moisture in the cap hole has no apparent effect. It is necessary therefore in setting a charge under water to pack soap, tallow, or even clay tightly and firmly about the cap after it has been inserted into the cap hole. Then the cover of the paper box is taken, cross slits are cut in it, the fuse is led through these slits and the cover is pressed firmly on to the clay so that the latter will not

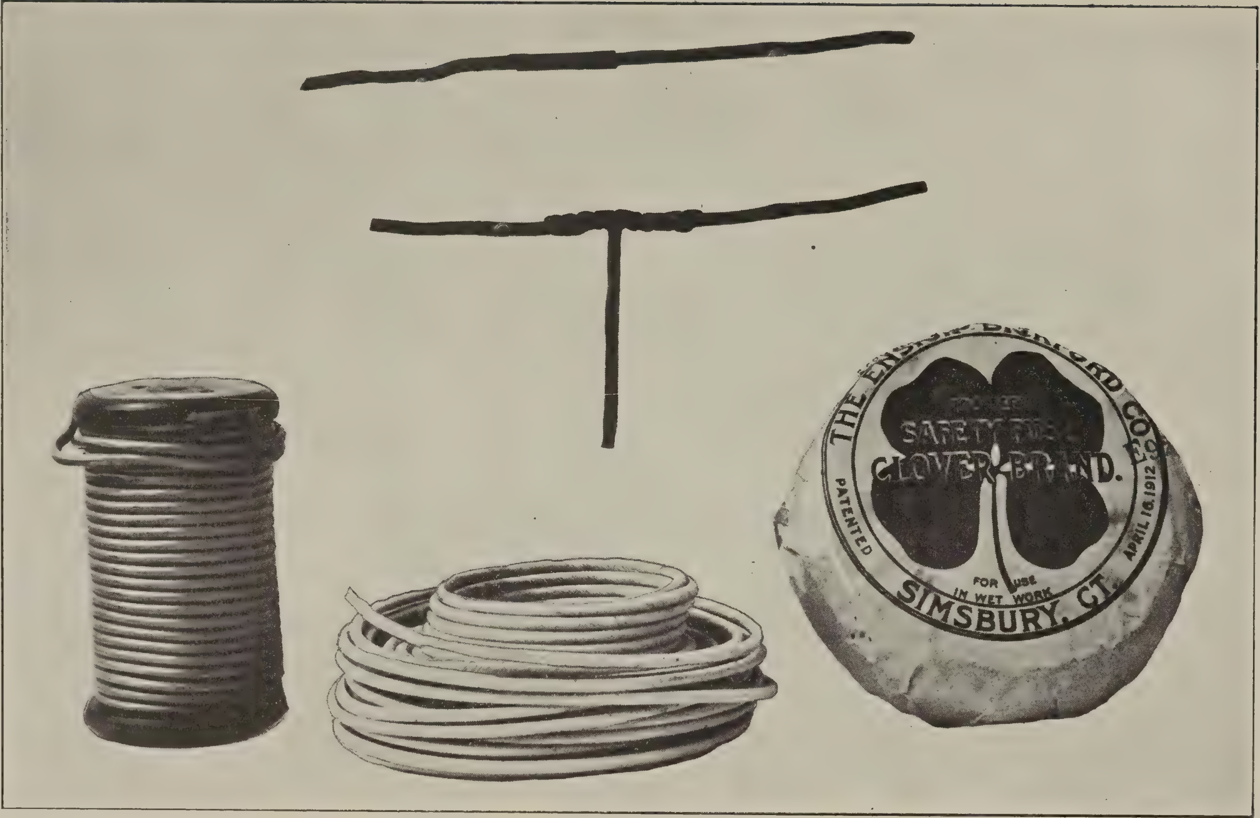

CLOVER BRAND.
PATENTED
APRIL 16, 1912
FOR USE IN WET WORK
SIMSBURY, CT.

Fig. 3. Butt joint in detonating cord. Joint between main and lateral of detonating cord. Spool of detonating cord (20 yards). Safety fuse loose and in original package.

be washed away after the charge is set. The other blocks in the charge should be kept in the paper boxes. If these precautions are observed, charges can be set under water and remain there for several hours before firing.

Our explosive in its present form and, in fact, our whole demolition equipment may be said to be in only an advanced experimental stage. It is not quite so convenient nor so powerful as the foreign equipments, which have been worked out at great expense, but on the other hand it appears to be efficient and reasonably satisfactory. Further experimental work will be undertaken from time to time until such imperfections as make themselves evident are remedied. In the meantime it is at least a consolation to know that we have finally a standard form of explosive and that it does not have to bear a foreign trade-mark.

Field Fortifications Based on Practical Experiences of the Russian-Japanese War*

I. WAR EXPERIENCES AND HOW TO UTILIZE THEM.

The Russian-Japanese War enhanced the value of field fortifications very much; from it may be learned the lesson that field fortifications are valuable for the offensive as well as the defensive.

The practical use of fortifications during the campaign were most numerous, and an especially noticeable point was the fact that, owing to various special works upon which they were engaged, it was not possible to employ engineer officers in the supervision of the construction of fortifications. Almost without exception each detachment was forced to supervise and execute its own works. Such being the case it followed that improvement of the terrain, construction of field works, etc., were under the direction of infantry officers. Therefore training in peace time in this duty is most important.

The reason why we wish to add such a course of study to our military education is because we recognize its great value. There is, however, one great difficulty in its accomplishment—the public, unlike military men, dislikes the work of fortifications. This dislike must first be rooted out. However difficult it may be, there is no good reason for delaying its incorporation into the new course of study. It is very necessary that this matter should be decided quickly and properly; the officers especially should be made to understand this subject thoroughly, so that their study may be increased through their interest in the work.

In order to accomplish this, in ordinary cases, it would be well to have the plan of fortifications which the army is to use, made uniform; its execution can then be uniform and it will be easy of comprehension by all officers. Officers should be able to comprehend simple plans, even without detailed explanation. At any rate, ununiform execution, the lack of mutual cooperation, or the improper or disorderly practical application of entrenching, can not be permitted for a moment. In other words, although those who have sufficient judgment with respect to terrain and the re-

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*Reprinted, by permission, from the January, 1914, number of the *Journal of the United States Cavalry Association.* The *Journal* kindly furnished all the illustrations. Originally translated from the Japanese by Lieut. Charles Burnett, Fourth Cavalry, Military Attaché at Tokyo, Japan.

quirement of the defense can easily decide what intrenchments are necessary, it is important that every one should be able to execute such engineering work in a fairly satisfactory manner. They must know, especially, what worthless intrenchments are.

However, the first thing to be careful of is excessive haste in always constructing fortifications without regard to time or position. Not only is the work improperly done, but its value is greatly lessened thereby. Intrenchments should only be constructed when convinced of their necessity and advantage, and their actual construction must be carried out at an advantageous time. If conditions have been judged wrongly, no necessity for fortifications will arise, and their occupancy may be actually harmful. In such cases, their use must not be forced in order to prevent the entire work from becoming useless labor, or through shame arising from the mistake made. On the contrary, conditions may be such that while already completed works can not be used often, that is no reason for considering them entirely useless. If they be defended with bravery, endurance and resolution at the time of the attack, they will prove their value.

Even private soldiers must be made to understand that, though they may temporarily assume the defensive while awaiting an opportunity for taking the offensive, they must never simply lie behind their intrenchments and make a passive defense. When the opportunity comes, they must drive out the charging enemy with the bayonet, or, while one section of the line is held firmly, the reserve will drive out the enemy who has penetrated our position; or, during the enemy's attack, we will select a good opportunity, assume the offensive ourselves and pursue the beaten enemy.

At the beginning of the Japanese-Russian War, only half of our soldiers carried intrenching tools, but toward the end of the war almost all carried them; in actual warfare they were not found useless by any means.

II. PLANS.

In the attempt to make military men understand the practical application of field fortifications, one great obstacle is encountered. That is, the question as to what kind of works will be constructed, and the computation of detailed plans therefor. Although people generally are deeply infected with the idea that such computations are very important, as a matter of fact it is quite unimportant in the field. Indeed, not only are such computations usually disregarded when works are actually constructed, but, if used, more inaccurate results will follow than if temporary measures, suitable to the terrain and existing conditions were followed.

Even though the commanding officer may be most skillful and able, and though officers may be in charge of the work, the preparation of many detail directions will take more time than the actual construction itself; and even after the work is completed, much time must be wasted in carrying out the necessary and unavoidable corrections. Even though such detailed plans be completed before the appearance of the enemy, after the latter appears, the commanding officer must acquire a clear knowledge of the situation before he can judge where to begin work. In the case of field fortifications (position fortifications), which must be executed during an engagement, confusion can not be avoided. All plans for such works are based on the fixed principles of science and must follow a common method; but at the same time their execution must be rapid and easy. The principal aim must be simplicity. Therefore in fortifications of the present day, detachments will never make the division of time and labor which so many people recommend. It should not be necessary for the commanding officer to take pencil and paper in hand, but he should be able to plan intrenchments quickly from horseback, just like any other tactical problem.

In the plan of such works, the smallest permissible unit is the company of infantry working with the short intrenching tool, one-half working at a time. Similarly, in the artillery the smallest unit is the battery using the tools which they carry with them. In each detachment, there will be indicated simply the line which it, alone, will fortify; this line always being limited to the detachment's sector of ground. In addition the artillery will be notified of the direction of fire. Although, of course, the commanding officer of each zone is responsible for the maintenance of his own communications and with communication with neighboring zones, this point must be borne in mind when orders for intrenching are given. When there is sufficient time, the long-handled tools will be brought up from the corps tool column, or, when the necessity arises, requisitioned intrenching and carpenters' tools will be used.

In general, it is a fundamental principle that intrenchments will be constructed by the troops which will occupy them later. Those detachments are responsible for the direct protection of their works and for the preparation of a reserve within their own sector.

III. ORDERS FOR INTRENCHING AND EXAMPLES OF EXECUTION.

(*a*) *Introduction.*

Fig. 1 shows the case of four battalions, or one regiment of infantry, entrusted with the defense of a front of 2,000 paces. Two battalions furnish the service of security and execute the work, while the other two form a reserve. When the hours of work are long, the reserve relieves the other battalions. Strong *points d'appui* are constructed, while the reentering part has a comparatively weak profile.

In Fig. 2, the enemy has approached within effective rifle range and the first period of occupancy of the works after the withdrawal of covering detachments is shown.

Fig. 3 shows the detailed subdivisions of the defensive line.

When the defensive line and the limits of the flanks, or its

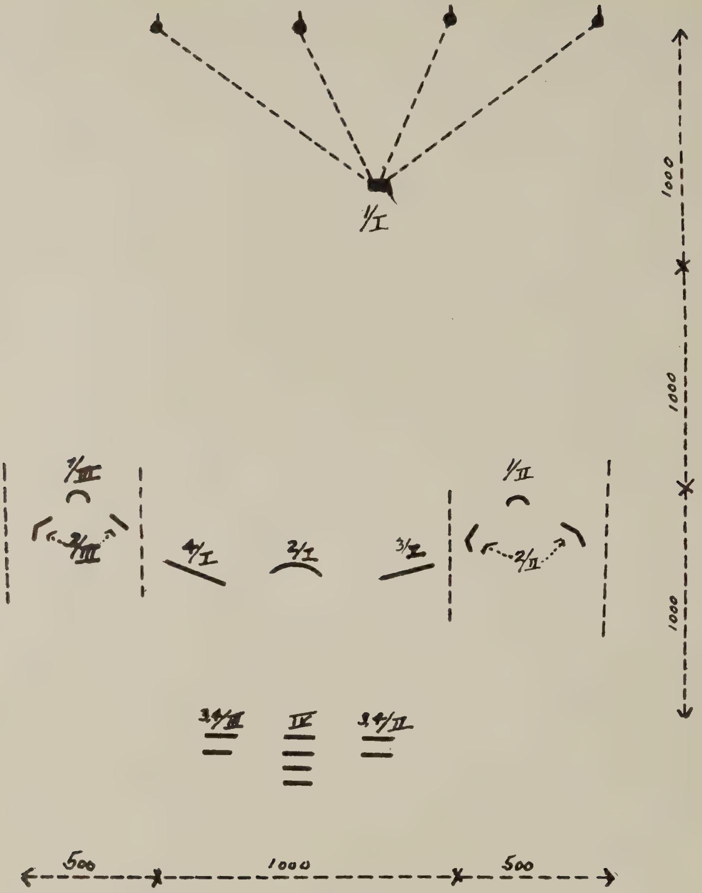
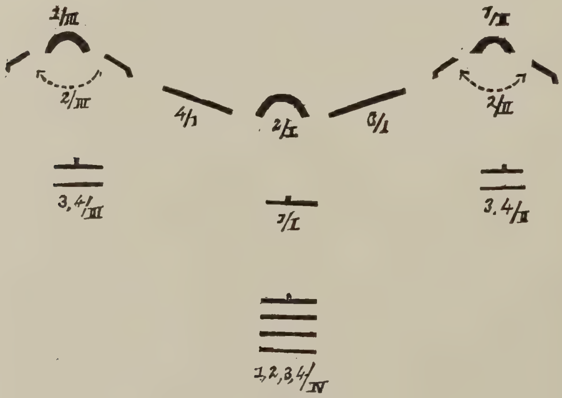

1/I
1000
1000
1000
1/III
2/III
4/I
2/I
3/I
1/II
2/II
3,4/III
IV
3,4/II
500
1000
500

Fig. 1.


1/III
1/II
2/III
2/II
4/1
2/I
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3,4/III
1/I
3.4/II
1,2,3,4/IV

Fig. 2.

breadth, are clearly shown by the map (it is much better to indicate the above on the ground itself), an infantry battalion begins its advance in the direction of the indicated line. If conditions permit, mounted officers may be sent ahead to reconnoiter the line where intrenchments are to be constructed, and they guide the different subdivisions to their proper places. Upon arrival at the position, those officers will use soldiers as markers to indicate both flanks of the line where the work will be begun, and the points of the curves as well. They will then order the work to be begun.

Whenever soldiers are used to mark the position, the position of the support and the mutual relations of each subdivision with respect to the line to be fortified, are clear at a glance. Not only is it possible to judge of its suitability or otherwise, but it has the additional advantage of enabling battalion and regimental commanders to easily and quickly rectify mistakes before the beginning of the work. In this rectification, it is sufficient to move the soldier markers to the desired position.

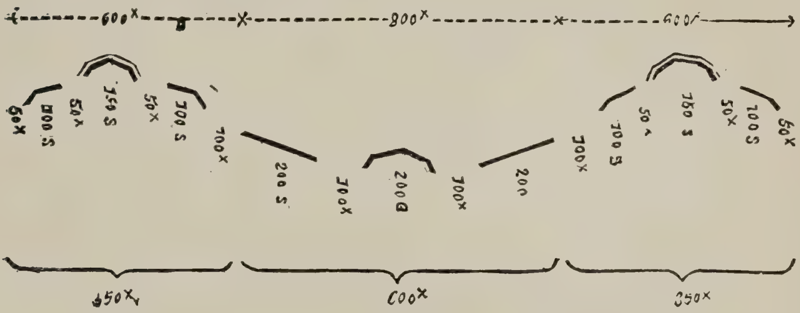


Fig. 3.

In order to divide the ground among the battalions, it is only necessary to mark two or three lines on the map or on the pencil sketch. Each battalion commander, or his adjutant, after examining the regimental commander's map, will copy the sector assigned his battalion. As everybody knows, forty-five minutes is required to construct the simple skirmisher's trench, while one hour and forty-five minutes is required for the complete trench. When such practice has been carried out two or three times, even non-commissioned officers understand how to direct the work.

The profile of the skirmish trench depends entirely upon the terrain. The parapet should only be of sufficient height to obtain a good field of fire; it is impracticable to state in figures what that height should be. According to the time that can be spent, the kind of trench—prone, kneeling, or standing—is indicated before the work begins; no other instructions are necessary. The most important matter at this time is that each man should be able to use the trench at any time without reference to the period of construction.

(b) *Shape of Profile; Models.*

From the experiences of the Japanese-Russian War, the parapet is made as low as possible, in order to make discovery difficult; in order to provide good cover for the men, the trench was made narrow and deep.

In accordance with the above principles, the prone, kneeling and standing trenches took the following forms (see Figs. 4, 5, 6). The limit is a height sufficient to cover the head and shoulders of a prone skirmisher. In special cases, as in rolling country, the profile can be changed as in Figs. 7, 8, and 9, so as to conform to the natural shape of the ground.

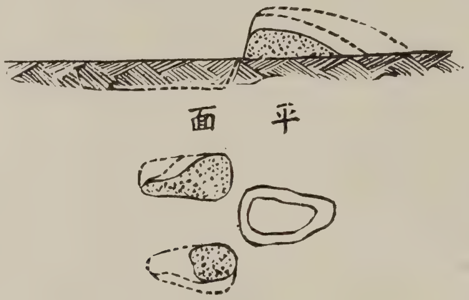


Fig. 4.

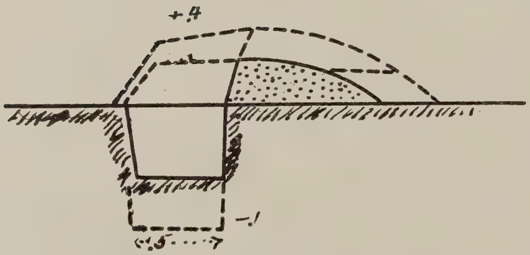


Fig. 5. Kneeling skirmisher's trench.

(c) *Drainage, Shelter and Clearing of Ground in Front.*

When the objective is defensive, and not merely a temporary matter the greatest attention must be paid to drainage. In the vicinity of Liao Yang, when the skirmishers' trenches and the artillery emplacements which had been constructed a long time previously were examined, all the ditches were filled with water from rains, and could be used but little or not at all. In one section of the battle line, a new artillery position had to be constructed during the battle. The offensive works of the German army at Metz and Belfort were practically useless from the same reason. Therefore drain pipes, or drainage holes must be constructed (see Figs. 10, 11, and 12).

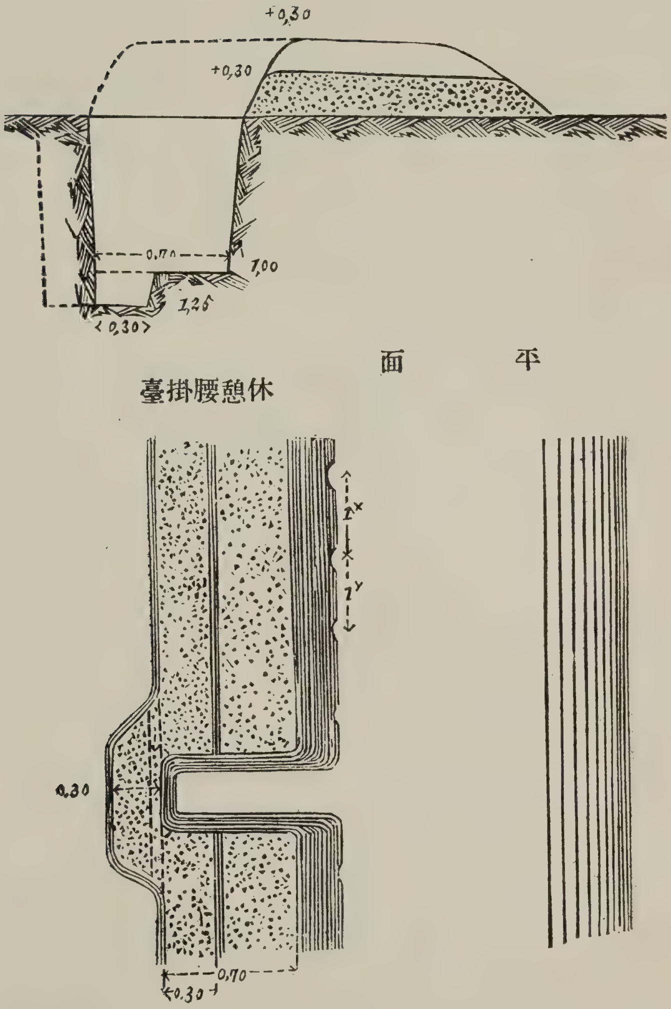
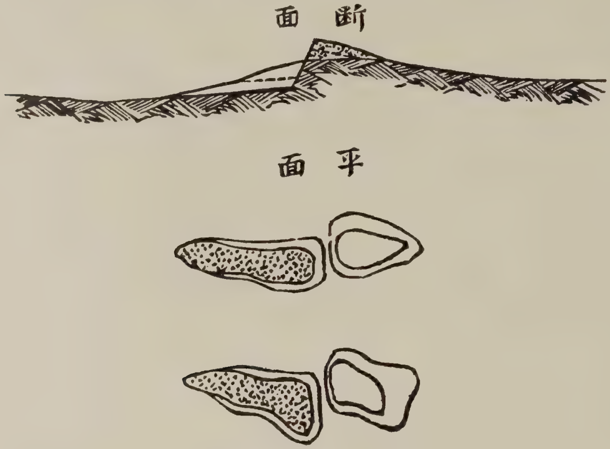

+0,30
+0,30
0,70
1,00
1,25
0,30
平面
休憩腰掛臺
1x
1y
0,30
0,70
0.30

Fig. 6.

Intrenchments should be constructed so as to make it as difficult as possible for the enemy to see them. Accordingly, the construction of cover is important, and as few points as possible should be intrenched. At the latest, the construction of cover will be begun at once after the construction of the parapet. However, in the case of intrenchments prepared beforehand, whenever it is desired to conceal such preparations, or render the reconnaissance of them difficult, cover will be constructed at various ranges in front of the position before the intrenchments are begun. Whenever the color of the excavated earth differs conspicuously from that of the surrounding ground, the parapet must be covered with dirt from the latter.



第八圖

伏姿散兵用

Fig. 7. Prone skirmisher's trench.

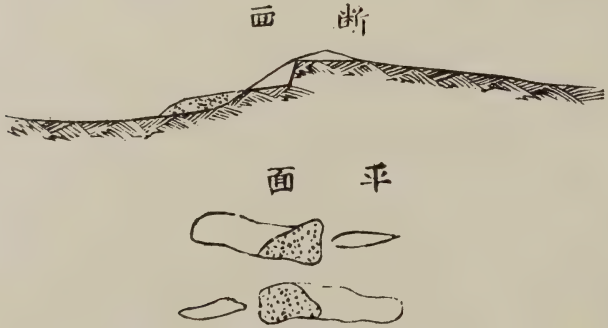


Fig. 8. Prone skirmisher's trench.

The clearing off of the foreground at the time of occupancy of the position is a most important matter. It not only increases the field of fire, but protects the defender from surprise and renders it difficult for the enemy to make a detailed reconnaissance of the position. In such cases, anxiety about the property of the natives, or a desire not to injure such property, will never be entertained. This matter involves the safety or danger of thousands of lives,

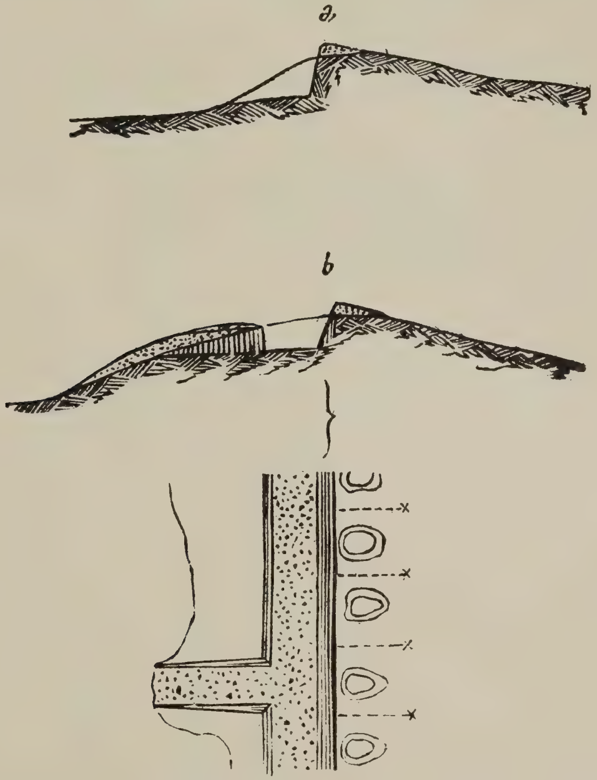


Fig. 9. Kneeling skirmisher's trench.

which must not be jeopardized for the sake of a little anxiety. If the natives suffer, it is an easy matter to assist them, or to reimburse them in some other way.

(*d*) *Manner of Using Intrenching Tools, and the Tool Column.*

According to the examples shown in Figs. 1, 2, and 3, in the detachment which is about to construct intrenchments in a defensive position, one-half are employed as a protective force and as a reserve. The other half engage in the work, one-half the number

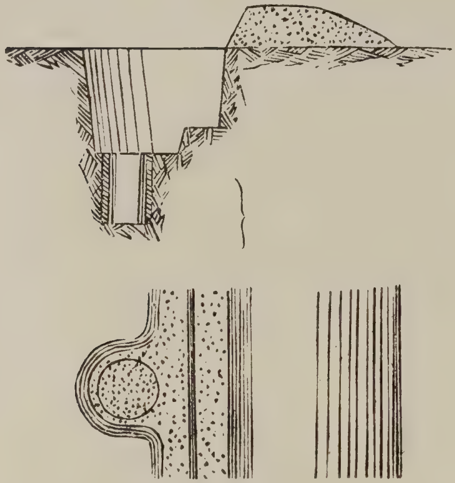


Fig. 10. Drainage pit.

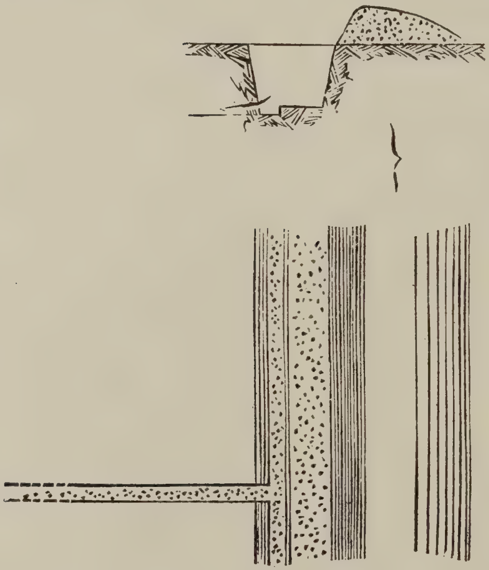


Fig. 11. Drainage ditch.

acting as a relief. The number of men working at one time does not exceed one-fourth of the whole detachment.

In hastily constructed intrenchments which have not been planned beforehand, nothing but the portable short-handled shovel is used; however, if it is desired to construct a strong profile and there is considerable time for its execution, or when it has been decided beforehand to intrench in that position, the long-handled shovel will be used. If this is done, it not only increases the rate

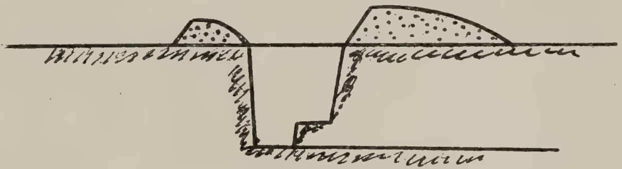


Fig. 12. Drainage ditch extending to the front.

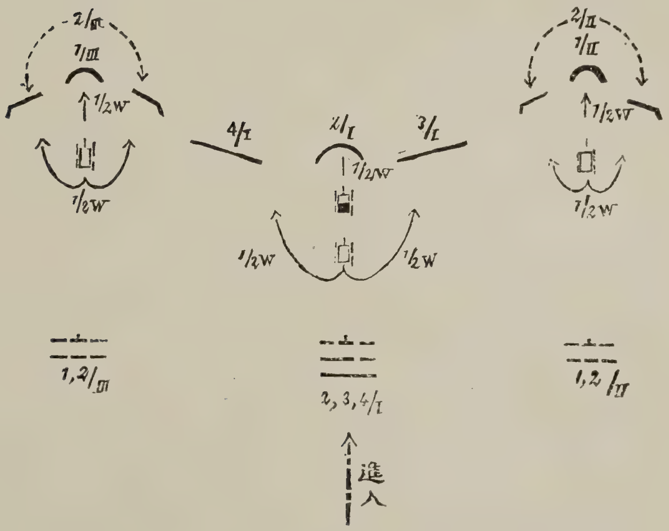


Fig. 13. Intrenchments made with long handled tools only.

of execution, but is much less fatiguing to the men in the same amount of work.

The tool wagon belonging to each corps has five wagons (numbered from 1 to 5). Each wagon has the followng tools: Shovels, 150; picks, 80 (total intrenching tools, 230); saws, 4; axes, 22 (total carpenters' tools, 26). Therefore, as a usual thing, the following procedure is followed in each detachment: To a half of each company, long-handled intrenching tools are distributed; if the work is carried out normally, the tools from each wagon will supply two companies (one-half battalion). If in each detachment only half of the men work at one time, while the other half acts as a guard and reserve where tools are not needed, one wagon from the tool column will be sufficient for each battalion. Therefore, the five wagons of the tool column will supply long-handled intrenching tools for five infantry battalions.

The small number of carpenters' tools loaded in each wagon will be used in clearing off the foreground and in constructing cover, by the deachment which is using the intrenching tools from the same wagon; they will be distributed at the same time as the intrenching tools. The pioneers belonging to each regiment will execute such special work as bombproofs, lookouts, drainage works, and generally all work which requires the use of carpenters' tools. Four wagons, as indicated in Fig. 13, will be sufficient for the whole work.

In such a case, of the four wagons assigned a regiment, two accompany the first battalion; of the other two, one each enters the position with the half of the second and third battalions. After they have arrived at the position, each company receives half of the tools from one wagon (75 spades, 40 picks, 115 tools in all). After the work has been completed and the tools cleaned, the wagon is brought to a point under cover, as near as possible to the position, in order that the tools may be reloaded.

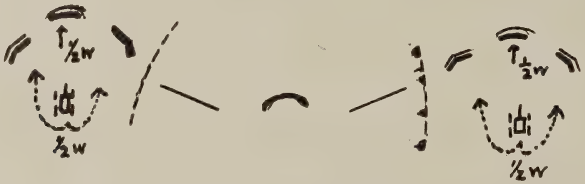


Fig. 14. Intrenchments made with long and short handled tools.

The excess tools in a wagon will be held in reserve, for it is a fundamental principle to always distribute the entire contents of a wagon to one unit. It is strictly forbidden to divide up the tools of one wagon among several detachments. According to this example, when long-handled tools only are used, five battalions can be worked at the same time, and a defensive work with a front of 2,500 paces can be constructed.

When the entire work must be finished at the same time and the salients are to be made strong with weak reentering angles in the intervals, long-handled tools will be distributed to those detachments only which are engaged on the salients on both flanks. Short handled tools will be sufficient for the intervals. This is because work can be done four times as fast with the long-handled tool, as with the infantry intrenching tool. In this case, two wagons will be sufficient for one regiment, the manner of distribution being shown in Fig. 14.

Similarly, to the second regiment, which is engaged in construcing two reentrants and one *point d'appui,* one tool wagon only is required; to the third regiment, two wagons are required. Therefore, in a division, three regiments are employed in the first line; if the other regiments be temporarily placed in rear as a reserve, the tools of wagons Nos. 1 to 5 will be sufficient to enable an entire division to construct hasty defensive intrenchments.

During the execution of the work, the interval between individual soldiers must be over one and one-half paces at the least; if the interval is less than this, experience shows that it interferes with freedom of movement and decreases the digging capacity of the soldier.

IV. TECHNICAL ARTILLERY WORKS.

Artillery, like the infantry, should be able to execute their own intrenchments and other defensive preparations. Epaulements are of the first importance, and, next, the repair and hasty construction of communications (lines of approach). By the latter is meant the construction of special artillery roads across difficult ground from the roads in rear to the artillery position. In order to make drainage easy, gun platforms will usually be constructed on the natural surface of the ground. If this is not done, more time will be consumed in the arrangements for drainage than in the construction of the epaulement.

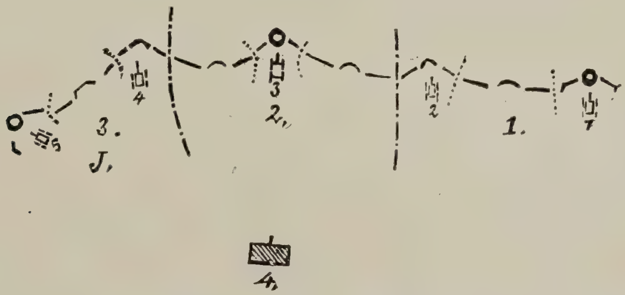


Fig. 15. Manner of intrenching a division with both long and short handled tools.

A work which contains several guns at small intervals is easily discovered by the enemy, and offers a favorable target for hostile fire; such an arrangement will be used only in special cases and for special reasons. As far as possible the gun epaulements must be suitable to the terrain.

With respect to communications, lines of approach suitable to the width of the carriage track will be constructed on uneven ground or on steep hill sides. Ditches, gullies and small streams which have steep rocky banks must be bridged; steep earthy banks will be cut and leveled. Existing bridges will be repaired according to necessity.

V. OFFENSIVE INFANTRY WORKS.

In order to forestall criticism, I must make an explanation here. At first glance, an attacking force would seem to require a great number of trenches, to be constructed on the skirmish line which is usually composed of more or less excited men. I will explain this matter:

The first consideration with respect to the foregoing, is that the effective fire of the enemy is never the same all along the firing line, because the effectiveness of that fire depends upon the configuration of the ground and the amount of defensive preparations of the enemy's line. However, the troops which advance in the first line, on account of the losses they have already received or are about to receive, must construct artificial cover. Cover will not be constructed at the same distance from the enemy, however, and there will be many small inequalities of the surface of the ground which will require but little alterations, or no technical work whatever, to be quickly made suitable for use. In addition there will be places within the zone of attack which the enemy can not see, and there will be more or less ground which he can not sweep directly with his fire. In such cases, a large part of the attacker's advance is not visible to the enemy; consequently in crossing that zone there will be no necessity of constructing trenches. Therefore, the necessity of intrenching from the longest ranges is entirely exceptional and will be required only in one part of the skirmish line. However, on entirely level ground in great plains which afford not the slightest cover, the regular attack as described in the Drill Regulations will be carried out step by step, with patience and resolution. At each halting place, during the advance from one firing position to another,individual cover for prone skirmishers alone is constructed.

In the advance from one such halting place to the next, soldiers, individually, will double-time, or in most cases, crawl. In executing the advance by rushes, sufficient preparations must be made beforehand by fire action. In the meanwhile, in each firing position, in order to obtain superiority of fire, the normal combat will be begun. Such a combat is seldom decided in a day; if the enemy fight stubbornly, the fight can be expected to last two or three days at least.

At the battle of Liao-Yang, the Japanese army began an infantry attack on the 1st of September; the first firing positions were constructed 1,000 and 700 paces from the enemy. In these positions, which were occupied for a long time, skirmishers' trenches were constructed. On the afternoon of the 2d, the first attack on the Russian position was made; the attack was repulsed, and we were forced back about 400 paces. Here we made a stand until dark, taking advantage of the trenches which had been constructed during the advance. On the night of September 2-3, skirmishers' trenches were dug 300 paces to the front; these trenches enabled us to repulse the Russian's counter-attack on September 3d.

The terrain often renders such difficult work unavoidable; and it is a great mistake to consider such experiences as entirely exceptional, and only liable to happen in weeks or months.

Intrenching is of such great importance in deciding the fate of battle that it is not at all unreasonable to require such hardship from the soldiers. As an example of great losses incurred when intrenchments are even partly neglected, there may be cited the instance of May, 1905, when three Japanese battalions advanced to the attack at sunset, from behind sand-bag cover at a distance of 400 paces from the enemy's line. After a fight lasting over twenty-four hours, they lost 1,297 men killed and wounded, that is, over 50 per cent of their total strength.

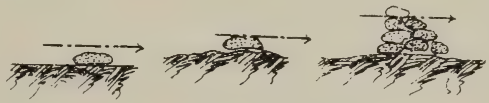


Fig. A.

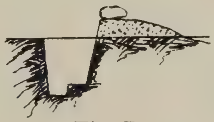


Fig. B.

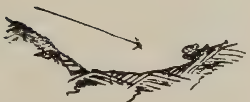


Fig. C.

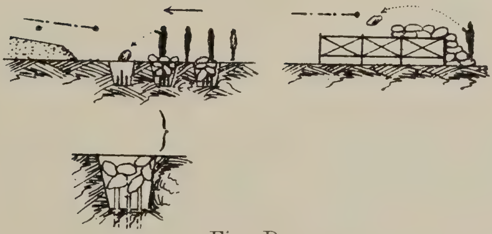


Fig. D.

THE USE OF SAND BAGS.

In wars of the present day, it is really surprising how often sand bags are used; by their use rocky ground or ground frozen in winter can be defended with intrenchments. Sand bags are comparatively light, occupy but little space, and have the advantage of being very cheap. For these reasons they can be easily prepared for each soldier; they can be easily transported, and can be used for many other purposes as well.

The technical method of using sand bags is shown in the following sketches. Fig. A: In rocky or frozen ground, shows the method of using sand bags as cover against fragments of shell. Fig. B shows how to use sand bags as head-cover. In such cases they will be distributed so as to be most convenient for individual soldiers. Fig. C shows an example of the use of sand bags for the protection of the head and body at the time of the advance over ground which is completely commanded by the enemy (defile, deep valley, etc.). Fig. D shows the use of sand bags in the passage of artificial obstacles (military pits, wire entanglements, etc.)

The obstacles used in the Japanese-Russian War were almost always wire entanglements, and military pits in which short stakes were erected. Abatis was seldom used on account of the scarcity of large trees. Abatis is only valuable when freshly made and its period of usefulness is very short. After it has once dried there is great danger of fire, as it is easily set on fire by artillery or by a special squad sent for that purpose. Therefore, it is not a good thing to use it in summer. Especially when abatis is used in front of and close to a position it is doubtful if the position can be held in case of fire. The enemy will take advantage of the fire to press to close quarters suddenly, and if the position has been wholly or partly vacated, will quickly charge.

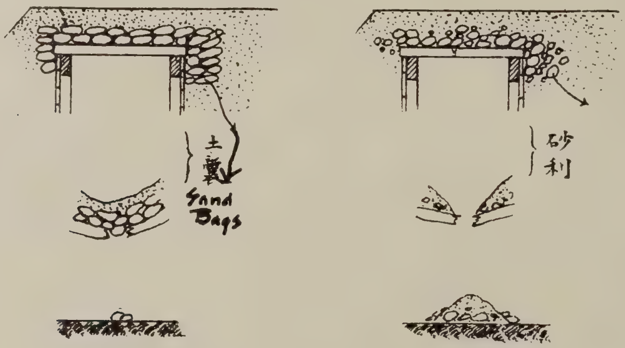


Fig. E. Bombproofs.

If materials for roofing (pebbles, crushed stone, sand, or sand and dirt) are used in sand bags in the construction of bombproofs, it will give great elasticity, good stability, and increase the resisting power.

The U. S. Seagoing Suction Dredge "New Orleans"

BY

Maj. EDWARD H. SCHULZ
Corps of Engineers

General Type. The dredge is a suction hopper type, with twin screws and twin rudders. The hull is of steel, and has a well in the stern in which the dredge-arm works. It is capable of dredging to a depth of 50 feet below the light-water line.

Award. The specifications for the dredge were advertised July 11, 1910, and bids were opened August 10, 1910. The award was made to the Fore River Shipbuilding Company for the dredge, and to the Frühling Suction Dredge Company for the dredge-head.

Built in Quincy, Mass., in 1912, by the Fore River Shipbuilding Company. Contract cost, $518,300.00.

General Dimensions. The dimensions of the vessel are as follows:

	Feet.
Length, over all (not including dredge-head)	315
Lengths between perpendiculars	300
Breadth moulded	50
Depth moulded	26
Length of hopper	93¾

Dredging Equipment. The dredging equipment consists of two 26-inch centrifugal pumps, with pipe connections to dredge-arm at trunnions and to deck pipes for overhead and hopper discharge. The hoppers have internal piping for pumping out same. The two 26-inch suction pipes along the dredge-arm terminate in a common dredge-head, which may be likened to a large hoe, 10 to 20 feet wide, which sinks into the bottom and receives the material to be dredged.

Boilers. There are four Babcock & Wilcox water-tube boilers, designed for a working pressure of 200 pounds per square inch. There is also a small upright auxiliary boiler. The four Babcock & Wilcox boilers are semi-marine, water-tube; length, 13 feet 6 inches; width, 13 feet 4½ inches; 12,664 square feet heating surface and 317 square feet grate surface.

Engines. The dredge is fitted with four triple-expansion, surface condenser engines for working with steam at a pressure of 200 pounds per square inch, exhausting into a condenser common to all four engines, with independent circulating and air pumps. The engines are all triple expansion, 12 by 19 by 32 by 24 inch stroke. When dredging, the two after main engines drive the twin propellers and the two forward engines the dredge pumps. When under way, both sets of engines can be connected for propulsion. In practice, they are not connected unless the run is to be a long one. Each engine was designed for and has developed 625 horsepower, with an average piston speed not exceeding 700 feet per minute.

Electric Plant. Two independent steam turbines (horizontal, Curtis), direct-connected to two 25 K. W. dynamos, are provided for lighting the ship, both above and below, and for signal lanterns and searchlight. Each engine is of sufficient capacity to do all the electric work of the dredge. These electric generators also provide power for ventilating fans and blowers and refrigerating engine, and for G. E. searchlight, 18 inches 35 amperes.

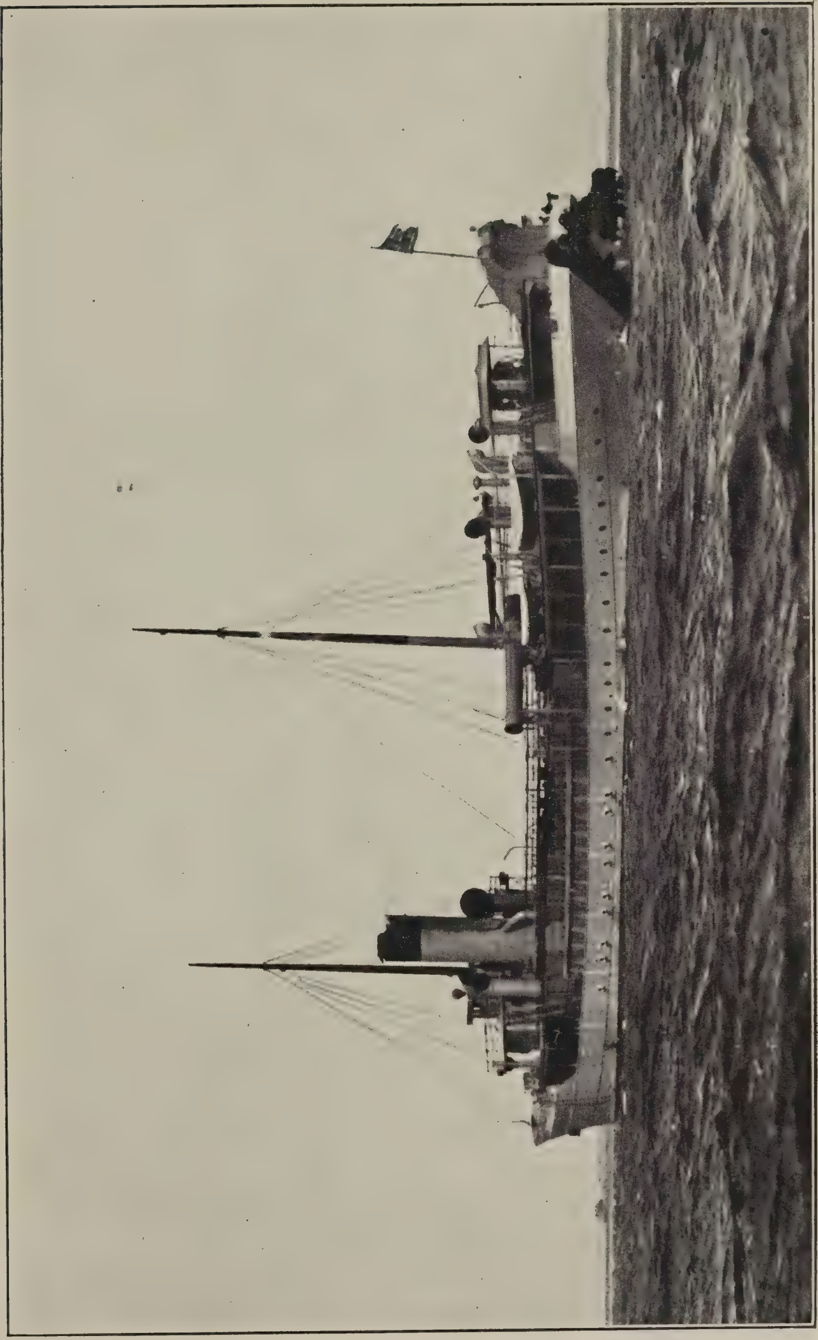
GENERAL DATA.

Crew: Working 13 to 15 hours, 56 men; working 24 hours, 73 men.

Draft, light: Forward, 14′ 3″; aft, 16′ 3″. Loaded: Forward, 23′ 6″; aft, 24′ 7″.

Displacement, light (mean draft 15′ 3″)	4,775 tons, actual.
Displacement, loaded (mean draft 24′ ½″)	7,940 tons, actual.
Total indicated horsepower of pumping engines	1,230 at 156 rev.
Total indicated horsepower of propelling engines	940 at 110 rev.
Total indicated horsepower of both sets of engines coupled to propeller shafts	2,354 at 140 rev.
Capacity of the 10 hoppers	3,102 cu. yds.
Revolutions of pumping engines	156
Revolutions of propelling engines:	
Light	110
Loaded	90
While pumping	0 to 90
Average speed:	
Light	8 knots.
Loaded	6 knots.
While dredging	½ to 1½ knots.

Trial Run: Dredge loaded to 20-foot draft, average speed for four (4) hours was 9.06 knots. Allowable load is 24 feet 7 inches



The U. S. Seagoing Suction Dredge *New Orleans.*

draft. This corresponds to a load of 2,350 cubic yards of sand, the bunkers full of coal; or 3,000 cubic yards of sand, with some of the bunkers and tanks empty. The sand weighs 3,310 pounds per cubic yard, and full hopper capacity of 3,100 cubic yards of sand can not be carried.

Dredge Arm and Suction-head. The peculiar feature of this dredge is the suction-head. This is of the Frühling type, and is at the end of the drag-arm, which is hinged and suspended from the stern of the vessel.

The dredge arm is a girder, and measures 68 feet 6 inches between trunnion centers and dredge-head axis. It is built up of steel plates and angles attached at each end to steel castings of extra good quality. The two 26-inch steel suction pipes are built into and form part of the dredge-arm. The steel castings (trunnions) at the forward end of the arm work in steel trunnion bearings forming part of the hull in the well. To the castings at the after end of the arm are attached, first, the suction-head trunnions, and then the suction head. Both the suction-head and suction-head trunnions were made of Vanadium cast-steel. The castings at the ends of the dredge-arm are hollow and form part of the suction pipe.

The original suction-head is made of segments of three widths, and can be made 10 feet, 16 feet 8 inches, or 20 feet wide. The pressure water (200 pounds per square inch) can be used as jets on the cutting edge to loosen hard material, or as mixing water inside the head when the mud is thick enough to choke up the suction to the pumps. The opening in the suction-head is controlled by portable baffle-plates.

The suction end of the arm is attached to the special hoisting winch at the stern of the dredge, by two 1¼-inch diameter extra pliable plough-steel cables. These cables are played in and out, depending on the depth and character of material. At about the center of the dredge arm are two oak guides with steel wearing plates that work on steel rubbing plates on the sides of the well. The dredge-arm, including the suction-head, weighs about 60 tons.

Pressure Pumps. There are three pressure-water pumps connected with two 9-inch pipes leading to the dredge head, and, with other pipes, to the hoppers. These pipes furnish water to the dredge-head and hoppers for loosening and mixing the material when necessary.

Modified Suction-heads. Two other suction-heads have been made.

One of these is similar to the type of drag generally used on the other hopper dredges, with the bottom built like a grating; this one has not been tried. The other is a modified Frühling head, in which the side and bottom projections have been eliminated and the bottom rounded; this head seems to be more efficient than the original where the material is hard clay and sand, or clay with 2 or 3 feet of sand on top. In favorable weather, the dredge is able to drag this head over the bottom and scrape the material from the top. In both the new heads, the pressure water is discharged at the cutting edge to help loosen the material. The two new suction-heads are made of cast iron.

General Equipment. The general equipment of the dredge is the following:

Hopper doors: 6′ 8″ by 4′ 2″, framed of steel and wood, and closing wood to wood, with leather stop waters.

Hopper-door mechanism, of hydraulic type, with 4 rams connected to hopper doors by chains. Cylinders, 16″ in diameter by 48″ stroke, 300 pounds pressure.

Dredge Pumps: Shaft, 10″ in diameter. Impeller secured to shaft by feather and nut. Impeller nut protected by steel cap. Impeller 81″ diameter. Pump casings protected from wear by cast manganese steel liners. Side liners ground and impellers machined to leave ⅛″ clearance on each side of the impeller.

Propeller wheels are 4-bladed, built up, with blades of manganese bronze and hubs of cast-steel. Diameter, 10 feet; pitch, adustable, placed at 8′ 6″.

Propelling and pumping engines are operated by double eccentric Stephenson links and reversing cylinders and shafts.

Steam reversing gear for each main engine has cylinders 6″ by 12½″.

Two 6″ by 6″ Williamson Bros. steam-steering engines, direct-connected to the quadrants, and operated simultaneously from the pilot-house by hydraulic telemotor gear, or from after bridge by steam-steering gear.

1 winch, Lidgerwood, steam, two 8¼″ by 10″ cylinders.

1 special dredging winch, steam, Lidgerwood; double cylinders, 12″ by 12″, with reversing gear. The two wire falls from the dredge-arm are secured one to each drum, and are of extra pliable plough-steel wire, 1¼″ diameter. The machine and engine so proportioned so that when there is a pull of 10 tons on each fall, the winding speed is 50 feet per minute.

1 No. 9 Hyde Combination Steam and Hand Windlass.

3 No. 3 Hyde Steam Capstans, with double cylinders, 7″ by 8″.

Auxiliary Condenser, with combined air and circulating pump; Blake; size of pump, 12″ by 14″ by 14″ by 16″.

2 main 12″ circulating pumps of the volute centrifugal type, with brass shafts and runners and operated by independent engines, 8″ by 8″; either or both may be used.

Boiler Feed Pumps: 4. Vertical, duplex, brass-lined. Blake. 10″ by 6″ by 10″. Two are used as hydraulic pumps; all four interchangeable. Boilers are also equipped with two No. 8 Korting injectors.

Pressure Pumps: 3. Vertical, duplex, Blake; each pump having 2 double-acting steam pistons, 12″ in diameter, and 2 double-acting water pistons, 10″ by 12″ stroke.

Service Pumps: 3. Brass-lined, duplex, 5½″ by 6″ by 5″, Blake.

Fire Pump: 14″ by 7″ by 10″, Blake.

Main Air Pump: Blake, size 10″ by 22″ by 15″.

There has been added 1 Blake pump, size 5¼″ by 4¾″ by 5″, for water service to bearings in dredging pumps, and 1 Worthington pump, 9″ by 5¼″ by 10″, for sanitary pump; old sanitary pump now used in refrigerating room.

Feed-water Heater: 40″ diameter; 67″ high; Griscom-Spencer, type J, 47-coil. Working pressure, 200 pounds.

Evaporator: 2 20-ton, multicoil; Griscom-Spencer, type F (Reilly).

Evaporator Feed Pump: Duplex, brass-lined; Blake, 5¼″ by 4¾″ by 5″.

Distiller: Multicoil, 16½″ diameter, 50″ high; 35 square feet of cooling surface. Griscom-Spencer, type C.

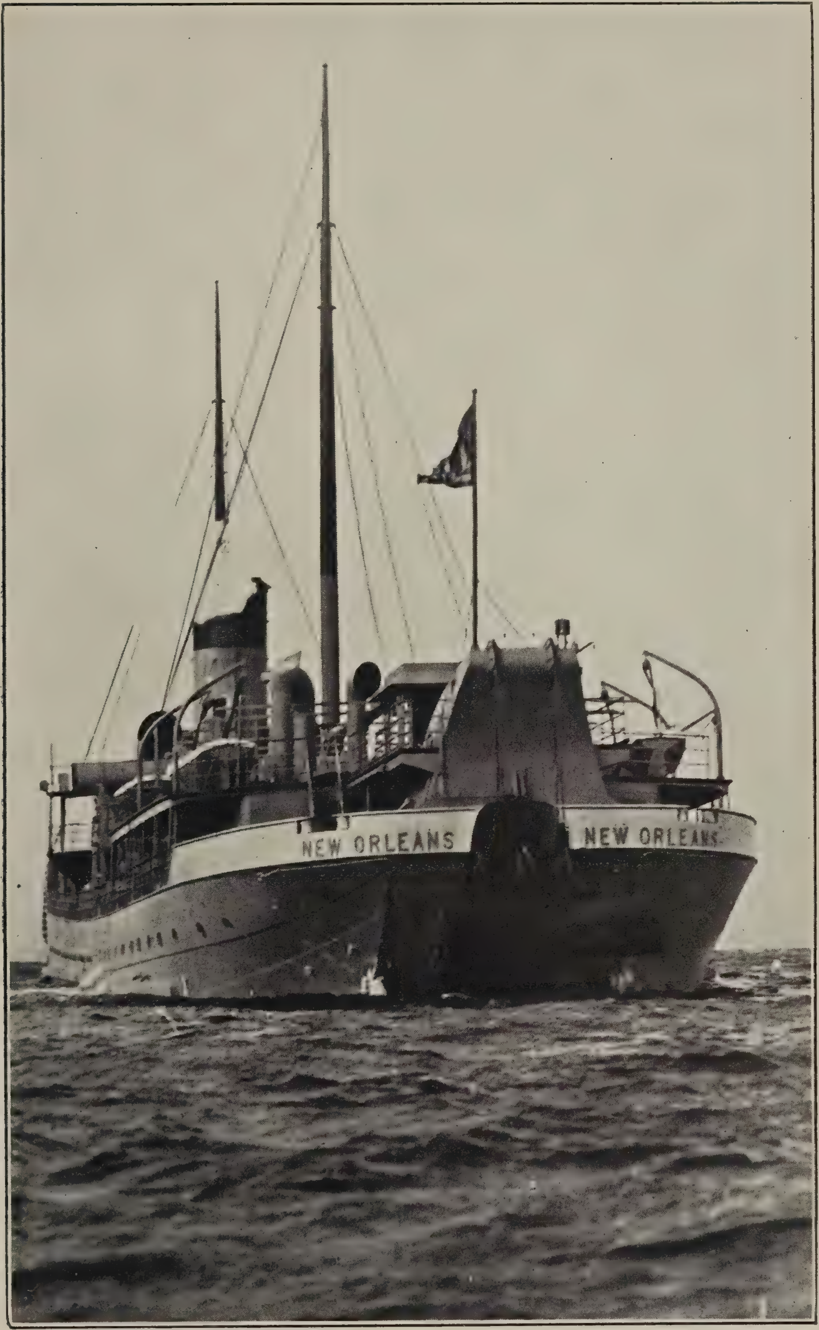
Fresh-water Filter: 13″ in diameter by 17″ high; Griscom-Spencer (Reilly).

There is 1 No. 5 Blackburn-Smith feed-water filter and grease-extractor.

Refrigerating Plant: Direct expansion. Anhydrous ammonia. Remington Compressor, 4½″ by 9″. 4 tons capacity. Operated by 10 H. P. Crocker-Wheeler motor.

Refrigerating Room: Holds 800 pounds of ice. 4″ cork insulation.

2 6″ ''See'' patent hydropneumatic ash ejectors; one of these discharges overboard and the other into starboard forward hopper.


NEW ORLEANS
NEW ORLEANS

Stern view; the U. S. Seagoing Suction Dredge *New Orleans.*

Performance of the Dredge New Orleans during the Fiscal Years 1912 and 1913.

	Fiscal year 1912.	Fiscal year 1913.
Location	Southwest Pass.	Southwest Pass.
Average depth before dredging	24 feet.	24 feet.
Depth after dredging	30 feet.	31 feet.
Character of material	Sand and mud.	Sand, mud and silt.
Average distance to the dump	2 miles.	3 miles.
Quantity dredged during year	186,515 cu. yds.	1,280,054 cu. yds.
Dredge began operations Apr.12,'12.		
Total number of loads	187	934
Number of loads per day, working	3.9	4.28
Average quantity per load	997.4	1,371
Average quantity per day	3,885.7	5,871
Average quantity per hour	399.7	786.75
Percentage of time pumping	29.50	18.58
Percentage of time going to and from dump	14.30	8.23
Percentage time from other causes, including time at night when not working	56.20	77.19*
Total hours of all service in year	1,056	8,760
Operating cost for the year	$21,009.06	$82,085.49
Average cost per hour at work	$29.51	$23.35
Number of days on which any dredging was done	48	218
Average number of working hours per day	14 hrs. 40 min.	16 hrs. 7 min.
Average time to dredge one load	1 hr. 39 min.	1 hr. 45 min.
Average time to dump	13 min.	12 min.
Average time going to and returning from dump	48 min.	46 min.
Total cost during the year	$23,199.06	$92,730.22
Cost per cubic yard, without repairs	$0.11 1-10	$0.06 85-100
Cost per cubic yard with ordinary repairs	$0.12 4-10	$0.06 88-100
Total cost per cubic yard, with extraordinary repairs	$0.12 4-10	$0.07 24-100
Fuel, tons	1,411.74 (15,686 bbls.)	6,753.64
Cost per ton, 11 1-9 bbls. (180 lbs.) =1 ton	$4.00 a ton.	$3.95 a ton.
Fuel, per cubic yard dredged	15.12 lbs.	10.55 lbs.
Total mileage of dredge	1,152.	4,813
Total cost per yard-mile	$0.06 1-5**	$0.02 41-100

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*The item, hours not working, includes nights when the dredge had a single crew. The dredge was laid up for extraordinary repairs 1 16-30 months, and under operation 10 14-30 months. Final dredging test for soft mud was made in Southwest Pass November 4 to December 4, 1912.

**The *New Orleans* was completed January, 1912, arriving at New Orleans March 23, 1912, and was accepted on March 31. The operating, 30 day, trial, was commenced on April 11, 1912, and completed on May 31, 1912.

For the fiscal year 1914, the dredge removed up to April 1, 1914, 1,060,969 cubic yards, at the rate of 909.6 cubic yards per hour pumping. Operating cost, 6.07 cents per cubic yard.

Dredging Tests. These were made off Provincetown, Mass., in sand and shells; in the Delaware River, in mud; and a thirty-day trial in Southwest Pass, in soft mud. The Delaware test was for 2,000 cubic yards sand, or 4,000 cubic yards mud, per hour, and the Southwest Pass test was for 4,000 cubic yards mud per hour.

The actual dredging results in the Delaware were 6,642 cubic yards per hour, in mud, and 3,072 cubic yards per hour, in coarse sand.

Test at Southwest Pass. The test at Southwest Pass was made from November 4 to December 4, 1912, and included the following features:

(a) Two mid-depth samples were taken from each load, from which an average sample was obtained.

(b) A reading of the samples for settlement each day until the twelfth day.

(c) The percentage of mud after settlement.

(d) The bin capacity.

(e) The amount of mud per load, based on (c) and (d).

(f) Time of pumping.

(g) Pumping capacity of mud per hour.

(h) Location of dredging.

(i) Depths of dredging and remarks.

There were 118 loads during the test, distributed over twenty-one actual working days.

	Cubic yards.
Average quantity of mud per load	2,555.4
Minimum quantity of mud per load	1,996.4
Maximum quantity of mud per load	2,852
Total quantity of all loads for the month	301,530.8

The time of loading was 15 minutes for 13 loads and 20 minutes for all the others.

	Cubic yards.
Maximum capacity, mud, per hour on 15 minutes pumping	10,998.8
Minimum capacity, mud, per hour on 15 minutes pumping	7,746.9
Maximum capacity, mud, per hour on 20 minutes pumping	8,556.0
Minimum capacity, mud per hour on 20 minutes pumping	6,417.0

Material settled slowly, requiring about seven to nine days.

There was very little change after the ninth day. The portion of clear water in the sample on the first day was as follows:

	Per cent.
1st day	3.7
2d day	7.6
3d day	10.7
4th day	12.9
5th day	14.5
6th day	15.6
7th day	16.4
8th day	17.0
9th day	17.5

No change thereafter.

Performance in Mud, Southwest Pass Test. The percentage of mud and special readings were as follows:

3d load on November 4th. One reading after 13 minutes, the bins being full. Percentage of mud	50.4
Another reading directly when through pumping after 20 minutes. Percentage of mud	70.1
(If the percentage of material increased in direct proportion with the time, the second reading of load No. 3 of November 4th should be 20-13 of 50.4, equals 77½ per cent mud.)	
Third reading taken directly from the discharge pipe	83.6
4th load on November 4th. Reading when bins were full, after 12 minutes	57.8
Second reading at the end of 20 minutes when pumping ceased	72.2
(The second reading of this load should be 20-12 of 57.8, equals 96 1-3 per cent, if the percentage increased in direct proportion to the time of pumping.)	

The best results, dependent upon the time consumed, are somewhere between twelve minutes and twenty minutes—probably fifteen minutes.

November 5, load No. 5, was a special reading, directly from discharge, and showed 91.7 per cent mud.

The depth of dredging varies from 30 to 45 feet, the average being 36 feet. The general character of material where dredging is badly needed is hard sand, and in order to dredge mud, which was required for the test, localities had to be chosen where the depths were greater and dredging not so urgently needed at the time.

Average Performance, Southwest Pass Test. It will be noted that the average performance of the dredge was 7,891.6 cubic yards mud per hour, representing 82.5 per cent as mud. As a matter of interest, it was desired to know how much of this mud was actually solid dry material, and tests of the samples of three loads were made. It was found that, taking a sample of mud with all the free water removed, the dry material constituted 37.5 per cent by weight and 42.7 per cent by volume. The three samples taken were: November 5, load No. 3; November 6, load No. 4; and November 14, load No. 4.

The average of mud for 3 samples was____________per cent__	85.97
The average specific gravity of mud of 3 samples was________	1.374
The average specific gravity of dry mud powder of 3 samples was	1.210
The average specific gravity of the 3 samples with free water (based on s. g. of water at 1.026) was___________________	1.325
The average specific gravity of all samples (based on average percentage of mud of 82.5 and on average specific gravity of dry mud of 1.374) was_________________________________	1.313

Based on the percentage by volume of 42.7, the actual amount of dry material per average load was 42.7 per cent of 2,555.4, or 1,091.15 cubic yards, and for the entire month (301,530.8 cubic yards of mud) was 128,753.71 cubic yards of dry material. The average capacity per hour for dry material was 42.7 per cent of 7,891.6, or 3,369.7 cubic yards.

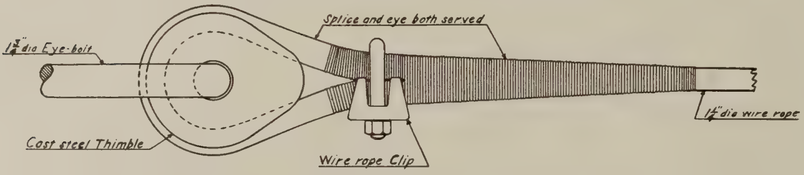
Results, Hard Fine Sand. The performance in hard fine sand, as found at times in Southwest Pass, has been about 800 to 1,000 cubic yards per hour. The dredge has shown herself preeminently capable of large performance in soft mud.

Accident to Dredge-arm. While at work about 1 p. m., September 23, 1913, on outer bar, Southwest Pass, about 1,100 feet beyond jetties, the dredge-arm suddenly parted its cables in and near sockets, dropping the dredge-arm to the mud. As far as could be determined, both cables, of 1¼-inch steel, broke at same time, the sea being not very rough.

Immediately after accident, on September 23, the emergency wire, 1¼-inch cable, was brought into play, but soon parted. Another wire was placed under the arm to hold the drag, but this parted at 1.00 a. m. on the 24th. About 5.00 a. m. another cable was placed, which also broke about 10.30 a. m. At 9.00 a. m. on the 24th the diver arrived, but could not reach the head, as it was buried too deep in the mud. The surging of the vessel made it difficult to do any further work. On the 25th and 26th, the sea was too rough. On the 28th, the tug *Donovan* went to the assistance. The dredge also worked her engines ahead and astern and filled and emptied her hoppers, but with no appreciable result. On the 29th, the dredge *Benyaurd* went to the assistance, by pulling on line ahead and holding the vessel in position. By these means, the arm was partly raised so that heavy tackle could be applied. During that night, however, one of the blocks of the tackle gave way. On the 30th, the placing of cables was repeated, with additional wires and tackle added. The diver replaced some of the bolts and nuts on the trunnion arms.

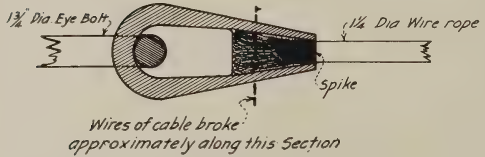
The process of dredging and moving ahead and pulling on the tackles was thus kept up from about the 30th of September to October 3d, and finally succeeded in raising the arm on the night of October 3.

PRESENT METHOD OF ATTACHING CABLE


Splice and eye both served
1¾" dia Eye-bolt
1¼" dia wire rope
Cast steel Thimble
Wire rope Clip

End of wire spliced around thimble

METHOD IN USE PRIOR TO BREAK OF CABLE
in Sept. 1913


1¾" Dia. Eye Bolt
1¼ Dia Wire rope
Spike
Wires of cable broke
approximately along this Section

In order to determine the cause of the accident and the strength of the 1¼-inch cable and the socket connections, tests were made at Tulane University. The socket connections, which were made similar to those that broke on the dredge, began breaking at loads of 44,000 and 38,200 pounds, respectively, and the maximum loads carried were 53,340 and 58,090 pounds.

A test was also made of one of the pieces of cable for breaking strain. The first break occurred at 63,000 pounds, and the maximum load was 89,000 pounds. The advertised breaking strain of this cable is 50 tons, or 100,000 pounds. The deficiency is, no doubt, due to the lack of strength of the leaded connection. This method of connection seems necessary, however, in order to apply the breaking test.

The method of socket connection in use at the time of the accident was as follows: The ends of the wire were passed through the socket; served inside the socket with wire; end unlaid; heart taken out; ends of wire bent over into socket; and spike driven into the heart. The ends were then seized together and pulled into the sockets with a tackle. After the end was pulled in, the socket was poured full of Magnolia White Metal, and allowed to cool.

The method of connecting the cables now adopted is as follows: The cable is spliced around a thimble, making a loop, which takes the place of the eye of the socket.

A sketch of the two methods is shown on opposite page.

Notes Upon the Water Hyacinth

BY

Capt. R. T. WARD
Corps of Engineers

In the spring of 1913 reports were received that the water hyacinth was obstructing certain of the small waterways near Mobile.

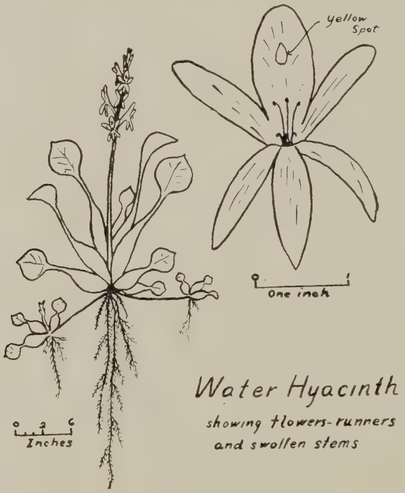


Fig. 1.

The writer investigated the subject and made a report from which the following notes are taken. These notes are compiled chiefly from the reports of the Chief of Engineers for the last fifteen years, and had to be collected before an investigation of the water hyacinth in the Mobile district could be made.

The water hyacinth is an aquatic plant which is a native of tropical South America. It is found in the waterways of Florida and the states bordering on the Gulf of Mexico. Whether it is indigenous or imported seems to be an open question. It grows in thick packs or masses, floats from place to place, and has become so abundant in certain streams in Florida, Louisiana, and Texas that it seriously obstructs navigation. In the last fifteen years several hundred thousand dollars has been spent by the Engineer Department in removing and attempting to remove the plant from certain streams and localities.

The following table gives a list of references in the Annual Reports of the Chief of Engineers relating to the water hyacinth:

Annual Report Chief of Engineers.	Subject.	Remarks.
1899, page 1613, also H. D. No. 91, 59th Cong. 3d sess.	Investigation of the extent of obstruction and remedies therefor. Report of special board.	A full report. Numerous experiments made. Recommended boats with crushing machinery. Log booms as adjuncts.
1901, pages 1746-341.	Spraying with Harvesta Compound. Experiments.	Recommended to be used in Florida.
1903, page 2433.	Full report on use of Harvesta Compound and its effects on cattle. Florida.	Recommended bicarbonate of soda instead of saltpeter in solution.
1905, page 1476.	Experiments with Department of Agriculture formula. Louisiana.	Recommended to be used. Cheaper than Harvesta Compound. Still in use in Louisiana.
1906, page 1235.	Experiments to determine solution not injurious to cattle. Florida.	Full report. No practicable solution found. Recommended to pull up and push away.
1910, page 433.	Hyacinth elevator put in use in Florida.	Still in use in Florida. Satisfactory.

The water hyacinth (*Pontedaria crassipes* or *Eichbornia crassipes*) is similar in appearance to the common pickerel weed or wampee (*Pontedaira cordata*). The water hyacinth differs from the pickerel weed principally in the shape of the leaf. The water hyacinth has a single petioled broad lance shaped and nearly circular leaf—while the leaf of the pickerel weed is heart shaped and oblong or lance arrow shaped obtuse. The leaves of the water hyacinth form a rosette, from 1 to 2 feet high, which remains above water as the plant floats. The stems of the leaves are generally enlarged, at the water surface and just above, into oval bulbs filled with air cells. This swelling is more pronounced in young plants or when the plant is growing singly or in small groups; in large groups the swelling is not very apparent. The flowers are on a terminal spike. The individual flower is about an inch and a half in diameter and has a perianth of six divisions. The upper three divisions form a lip of three lobes—the lower three divisions are more spreading. The upper lobe has a conspicuous yellow spot. The flower is very showy, being of a lilac rose color. When the flower fades, the stem bends sharply and immerses the seed pod. The plant is propagated both from seed and runners. The plant is aquatic; it usually floats on the surface of the water. Where the water is shallow the roots often become firmly attached to the soil. The roots are numerous and have a central wire-like stem, from all sides of which feathery filaments project. The roots generally form a dense brushy mass, in many cases reaching a length of over 2 feet. (Fig. 1.)

The plant seems to thrive vigorously during the fall after the rains set in. The winter frosts kill the tops and retard the growth of the plant. The plant grows vigorously for a short time in the spring and then nearly stops during the low water season—the leaf then assuming a yellowish tinge. During the first few years of its introduction it thrives vigorously at all times; after that it seems to have absorbed all the nutriment in the water, and the growth seems to be delayed until a fresh supply of nutriment is brought in during the flood seasons. The plant grows readily in brackish water, but it is killed by salt water. Plants immersed in salt water less than twenty-four hours have revived.

In 1898, the special board recommended against a chemical or a parasitic method and in favor of a mechanical method. In accordance with the board's recommendation, boats with adequate crushing machinery were authorized. Such a boat was equipped in New Orleans—with rollers to crush the hyacinth and log booms to aid in gathering the plants. This apparatus worked very well in Louisiana. No boat was built in Florida, action being delayed until the results in Louisiana were known. In 1900 spraying experiments were made with the Harvesta compound, made by the Harvesta Chemical Compounding Company of New Orleans. This gave satisfactory results at a much lower cost than the crushing method. The Act of 1902 gave "Authority to remove the plant by any mechanical, chemical, or other means whatever." In the fall of 1902 the Harvesta compound was being used with good results in both Florida and Louisiana. In the spring of 1905 a new spraying solution was used, prepared from a formula furnished by the Department of Agriculture. This solution gave the same results at a much lower cost. This solution is being used in Louisiana now.

In Florida the water hyacinth is largely used as fodder for cattle. Complaints were received from numerous sources that the spraying solution used was injurious to cattle. The River and Harbor Act of 1905 made an appropriation for removing the water hyacinth in the Florida waters, ''provided that no chemical process be used that was injurious to cattle.'' A number of experiments were made and it was found that there was no practicable solution that could be used that would not be injurious to cattle. Accordingly, in Florida the method was adopted of breaking up the packs and pushing them into the currents. In 1909 a hyacinth elevator was constructed, which operated in a satisfactory manner.

METHODS IN USE, LOUISIANA.

Fixed booms are constructed to prevent the hyacinth from moving from non-navigable to navigable streams. Movable and semi-automatic booms are constructed to prevent hyacinths from flowing from one navigable stream to another. Large areas are sprayed with the Department of Agriculture solution operated from a specially equipped spraying boat—the U. S. Steamer *Hyacinth*. Watchmen and laborers are employed to prevent the spread of the plant.

METHODS IN USE, FLORIDA.

The plant is gathered and piled in shallow water. A hyacinth elevator is used for this purpose which consists of a catamaran scow, equipped with an inclined conveyor driven by a gasoline engine. Booms are constructed across the mouth of sloughs and unnavigable streams and bulkheads are constructed to protect the channel.

SPRAYING SOLUTION.

The Department of Agriculture solution now used in Louisiana is: Dissolve one pound of white arsenic and one pound of sal soda in a gallon of water by boiling for about an hour and then dilute with about seventeen gallons of water preparatory to spraying.

COST OF SOLUTION.

This solution costs about ½ cent per gallon. One gallon will spray about 10 square yards of the plant. In Louisiana in the fiscal year 1912, the cost per gallon sprayed was $.016 and the cost per yard sprayed was $.0016. About 1,500,000 yards were sprayed by the U. S. Steamer *Hyacinth* during the year.

There appears to be no method that will completely remove the water hyacinth at a reasonable cost,although experiments have been made with every known chemical. Bodily removal is, of course, the most effective measure. This can be easily done with small areas. Spraying is the best method for large areas, but where the plant is eaten by cattle a mechanical device must be adopted like the hyacinth elevator that is used in the Florida waters. Good results can be obtained by closing creeks, bayous, and sloughs to prevent the movement of the plant to other waters.

WATER HYACINTH IN THE MOBILE DISTRICT.

The water hyacinth is known to have been growing near Mobile for at least ten or twelve years. It is impossible to ascertain how and when it was introduced—that is, if it is not indigenous. There are no large areas of it in the district, and in no places is it a menace to navigation. It is found in a number of the streams and waterways of the Mobile Delta, but generally in widely separated floating patches. From time to time some is seen floating in Mobile Bay. About ten years ago an attempt was made to remove a small area of the plant from a pond at Eight Mile Creek, near Mobile. The results were satisfactory at the time, but the plant is still found there in about the same quantity. Apparently, the conditions here are not favorable to the growth of the hyacinth. It is probable that the winters are too cold and also that the waters in the rivers in the southern part of the district are salt enough during low water season to retard the growth of the plant. The plant has never shown any tendencies toward rapid growth. All that is being done at the present time is to keep a record of new places where the plant is found, in order that prompt action may be taken if there are any indications of rapid spreading.

William Farrar Smith

BY

First Lieut. JOSEPH C. MEHAFFEY
Corps of Engineers

William Farrar Smith (see frontispiece) was born at St. Albans, Vt., on the 17th day of February, 1824, and was graduated from West Point in 1845, standing fourth in a class of forty-one. He was commissioned a Brevet Second Lieutenant in the Corps of Topographical Engineers, and was engaged for a year after graduation in survey work on the Great Lakes. From 1846 to 1848 he was Assistant Professor of Mathematics at West Point; upon the conclusion of this detail he returned to surveying, spending the next seven years in Texas and Florida. After another year as an instructor at West Point he was, in 1856, placed on light-house construction work, becoming Engineer Secretary of the Light-House Board in 1859.

After the outbreak of the Civil War he was on duty for one month in New York as a mustering officer, and was then placed on General Butler's staff at Fort Monroe for two months. On July 16, 1861, he was made Colonel of the Third Vermont Volunteers; on the 13th of August he was commissioned Brigadier General of Volunteers, and assigned to the command of the Vermont Brigade. A few weeks later he was placed in command of a division, with which he served in the defenses of Washington until March, 1862, and in the Peninsular Campaign, participating in the battles of Yorktown, Williamsburg, Fair Oaks, White Oak Swamp, Savage Station and Malvern Hill.

He was appointed Major General of Volunteers on July 4, 1862, and led his division in the Maryland Campaign, taking part in the battles of Cramptons Gap and Antietam. In November he was given command of the Sixth Corps, which he led through the unfortunate Fredericksburg Campaign. On March 4, 1863, the Senate having failed to confirm his appointment as Major General, he reverted to the rank of Brigadier General, relinquishing command of the Ninth Corps, to which he had been transferred in

February. After a short period in command of a division in the Department of the Susquehanna, he was made, in October, Chief Engineer of the Department and Army of the Cumberland, and, in November, Chief Engineer of the Department of the Mississippi.

It was in this position that General Smith best demonstrated the high order of his military abilities. He relieved a very serious situation at Chattanooga by devising and carrying out the plan whereby the Union line of communication was reestablished and shortened, and he also worked out all details of the plans for the battle of Missionary Ridge. With reference to his services here, the House Committee on Military Affairs reported in 1865 that "as a subordinate, Gen. W. F. Smith had saved the Army of the Cumberland from capture and afterward directed it to victory." In recognition of these services he was confirmed as a Major General of Volunteers in March, 1864. In May he was assigned to the Eighteenth Corps, which he commanded at the battle of Cold Harbor and at the siege of Petersburg until July 19, when he was placed on special duty under the orders of the Secretary of War. In November, 1865, he resigned his volunteer commission, and in March, 1867, his commission in the regular Army.

From 1864 to 1873 General Smith was president of the International Ocean Telegraph Company. In 1875 he was appointed a police commissioner for the city of New York, and soon after was chosen president of the board, holding this position until 1881, when he was made a Government agent and placed in charge of river and harbor works on the peninsula between the Delaware and Chesapeake bays. In 1901 he voluntarily gave up this appointment and lived quietly in Philadelphia until his death, which occurred on the 28th day of February, 1903.

There can be no doubt that General Smith was one of the ablest men developed by our great Civil War. He had a remarkably clear, orderly and comprehensive mind, and was most industrious and persistent in its use. General Grant wrote of him after the Chattanooga Campaign: "He is possessed of one of the clearest military heads in the Army—is very practical and industrious—no man in the service is better fitted than he for our largest commands." And later: "Really one of the most efficient officers in the service, readiest in expedients and most skillful in the management of troops in the field." This is a high opinion indeed, but it is one in which every thoughtful student of military history will heartily concur.

Winter Work in the Construction and Repair of Dams and Shore Protections in the United States Improvement of the Upper Mississippi River

BY

Mr. C. W. Durham
Principal Assistant Engineer

During the past four winters, considerable construction and repair work has been done in January, February, and March. At first the work was tentative or experimental, but the results, after men had accustomed themselves to conditions, have proved economical and now that several years have passed, are found to be durable.

Winter work was inaugurated in 1911 and carried on at several localities between Winona and Dubuque, partly by hired labor and partly under contract. Repairs were made during that year to eleven wing dams and one piece of shore protection and four small closing dams were built. There were put in place 17,782 cubic yards of rock and brush, the rock greatly preponderating. The average cost, 96½ cents per yard, compares favorably with that of work done during season of navigation, if the relative quantities of brush and rock are considered.

In 1912, at several points between Chimney Rock and Finleys, partly by hired labor and remainder by contract, twenty-five dams and five pieces of shore protection were repaired, three dams were built and three begun the previous season were completed. There were put in place 43,016 cubic yards of material, in about equal proportions of rock and brush, at an average cost of $0.846 per yard, a considerable saving as compared with similar open river hired labor and contract work of that year, which cost $1.033 and $1.084 per yard, respectively.

In 1913, between Dresbach and Finleys Landing, very successful and economical work was done entirely under contract, at several localities. Nineteen dams and eight pieces of shore protection were repaired and eight dams were built. There were put in place 49,933 cubic yards of material at an average cost of 89 cents per yard.

In 1914, work was done at a large number of localities under various agreements, between Nininger and Bellevue. Details of these operations are given farther on.

Summary of Winter Work, 1911-1913, inclusive.

Year.	Location and Designation.	How performed.	Material (rock and brush), cubic yds.	Cost.	Average cost per yard.
1911	Between Winona and Dubuque: Repairs 11 wing dams and 1 piece of shore protection; built 4 small closing dams.	Hired labor and contract.	17,782	$17,155	$0.965
1912	Between Chimney Rock and Finleys Landing; 25 dams and 5 pieces of shore protection repaired; 3 dams built and 3 completed.	Hired labor and contract.	43,016	36,396	.846
1913	Between Dresbach and Finleys: 19 dams and 8 pieces of shore protection repaired; 8 dams built.	Contract only.	49,933	44,444	.890

To insure the complete success of winter work as regards economy and rate of progress, a cold winter is needed in order that ice may form of sufficient strength to sustain the weight of sleds loaded with brush and rock to be hauled to the desired locality. But it is noted that even in very cold weather, air holes and weak ice often compel long detours.

No floating plant or machinery is required and the great cost of steamboats, barges, quarterboats, etc., used in open-river work, is eliminated. Teams are hired from farmers and others at a time when teams are not much needed for other work; labor is usually plentiful and men can be kept fully employed, either in getting out material or placing it in the work.

Only the part of the river above Rock Island is reliable for winter work, as below that point winters are generally shorter and of less severity as regards temperature. For winter work are selected dams to be built in shallow water, across bars or in chutes not accessible at low stages to boats and barges, and the material, especially rock, is mostly obtained from localities near at hand and

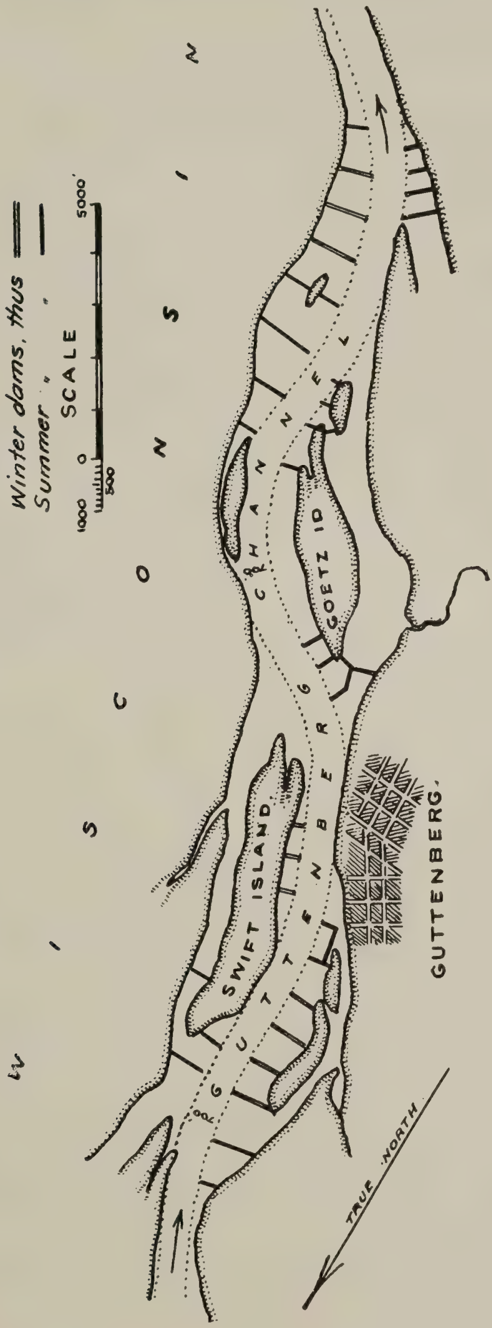

W I S C O N S I N
Winter dams, thus
Summer "
SCALE
1000
500
0
5000'
GUTTENBERG CHANNEL
GOETZ ID
SWIFT ISLAND
GUTTENBERG.
TRUE NORTH

Fig. 1.

perhaps inaccessible at any time to floating plant. In repairing dams and shore protections, and in building the latter, the depth of water is immaterial. There are large quantities of loose rock in the ravines of the adjacent bluffs which can be gathered and loaded on sleds or wagons very cheaply, but which could not be reached by barges on which to load it. Considerable rock is thus obtained for winter work without the expense of quarrying and the difficulties of obtaining and delivering brush are often much lessened. It is preferable to get the rock gathered up and ready for loading in the fall, and if any bank is to be graded for shore protection, it is done before the ground freezes. It has been found most advantageous to have the entire work done by contract, or agreement, as contractors are in better condition to keep their men fully employed, both in getting out material and in placing it, which the Government can not always do when it purchases the material on sleds or wagons at the site of the work and puts it in place by hired labor. A shortage of material, as frequently happens, keeps men, under these circumstances, partially unemployed. It has been demonstrated that contractors can make a good profit and at the same time perform the work at lower cost than the Government.

The specifications for rock and brush are the same as those used in hired labor and contract work during the open river season. "Brush which is made into bundles 20 feet long and from 9 to 12 inches in diameter, must be live, sufficiently trimmed and choked to form a compact mass and tied with four bands of lath yarn of not more than 120 strands, or with wire not smaller than No. 18; binding poles must be of straight wood at least 20 feet long, approximately 3½ inches in diameter at the butts and 1½ inches at small ends. When made into mats the fascines or bundles of brush shall be closely packed and secured by at least three pairs of binding poles, if required, joined by ties of lath yarn or wire about 2 feet apart. Mats shall be from 9 to 12 inches thick, unless otherwise ordered, and not less than 20 feet long."

The brush is delivered to the work on sleds or in piles on the ice. It is placed as in summer work, either by building mats, or with loose bundles where the water is shoal. Skids are used in launching the mats, after which they are placed in position and sunk.

"Rock must be hard, durable, and of a kind that will not disintegrate on exposure to the action of the water or atmosphere,

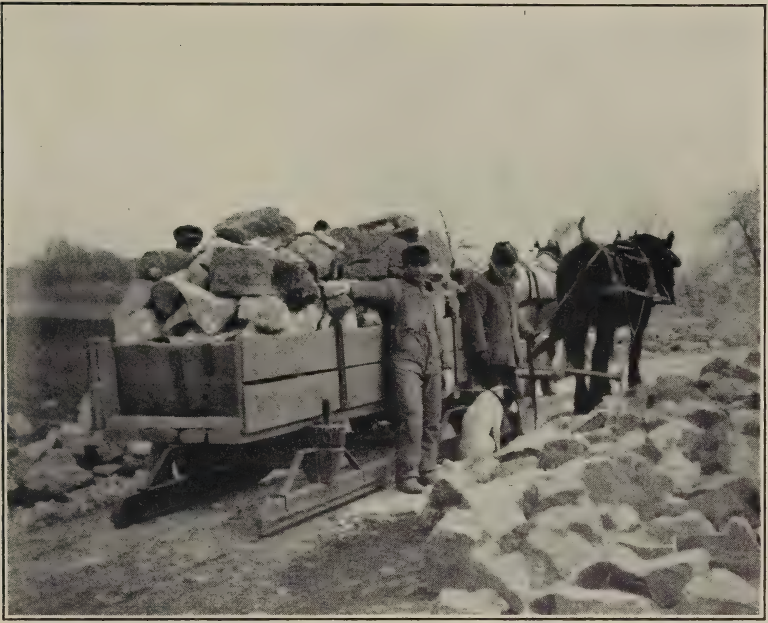


Fig. 2. Winter repairs; hauling rock on sled.

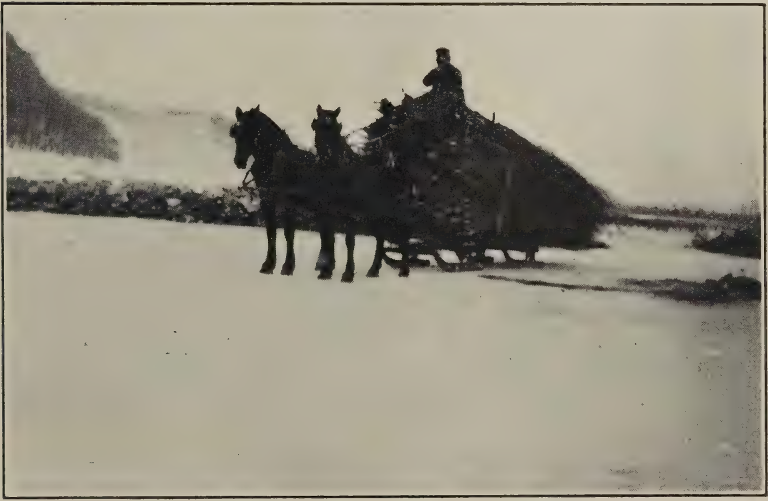


Fig. 3. Hauling willow fascines on sled to works.

and in pieces weighing 5 to 100 pounds.'' The rock is brought to the work on sleds or wagons and unloaded directly on the dam or shore protection. It is measured by the load and, as all racks on each job are made to uniform length and width, it is only necessary to measure the height of each load.

In making repairs of shore protections or in building them, the ice is cut away as the work progresses. In the case of dam repairs, the ice is cut or sawed along line of dam and below it for a width of 20 to 30 feet, and then sunk or removed to a distance, so that there will be no unnecessary weight near the opening. All new dams are built in the same manner, as below described. Beginning at the shore end two sets of binding poles about 10 feet apart are laid on the ice and securely tied into one continuous pole with wire or lath yarn. Brush is then laid on exactly as in summer work, making a mat 2 or 3 bundles thick, or as desired. Poles are then laid on top, tied together and to the lower poles at the proper intervals. After about 200 linear feet of mat has been built and securely tied, the ice is cut with a saw close to both butts and tips (the latter being always on the upstream side) from shore out to a point about 30 feet from end of mat. Rock is then thrown on the mat and the mat is sunk, except that the outer 30 feet remains on the uncut ice. The mat is continued without breaking from there on to outer end of dam in the same manner. Returning to the shore end, the same process is repeated until the dam is brought to grade.

In 1914, similar work to that above described was performed under contract at fifteen different localities between Nininger and Bellevue during the months of January, February, and March.

In the division *St. Paul to Winona,* work was done in vicinity of Nininger and Wilds Landing. At Nininger sixteen wing dams and their shore protections were repaired with rock only, at a cost of \$0.97 per yard in place, which was the cheapest work ever done in this part of the river, although inspection and overhead charges increased the cost to \$1.07 per yard. At Wilds Landing rock being the only material used, under contract at \$1.48 per yard in place, eleven wing dams were repaired and raised to grade, the cost being increased by inspection and overhead charges to \$1.57 per yard, a very cheap figure. The total quantity of rock used in this division was 8,101 cubic yards, which cost in place, including all charges, \$9,512.04.

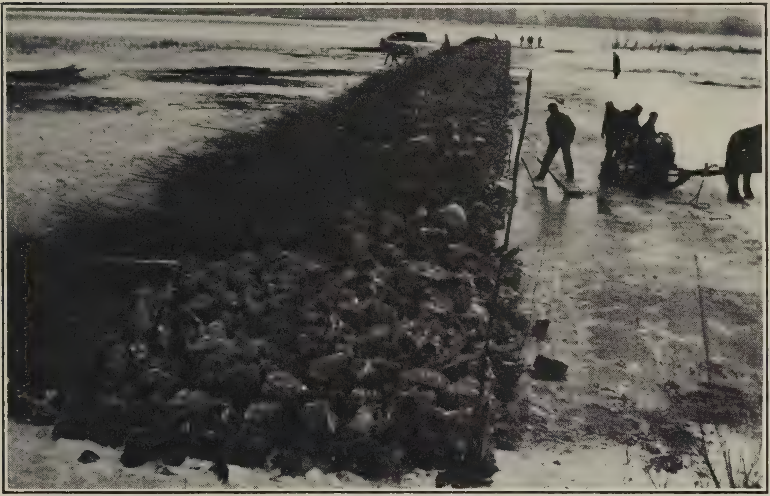


Fig. 4. Building a dam on the ice.

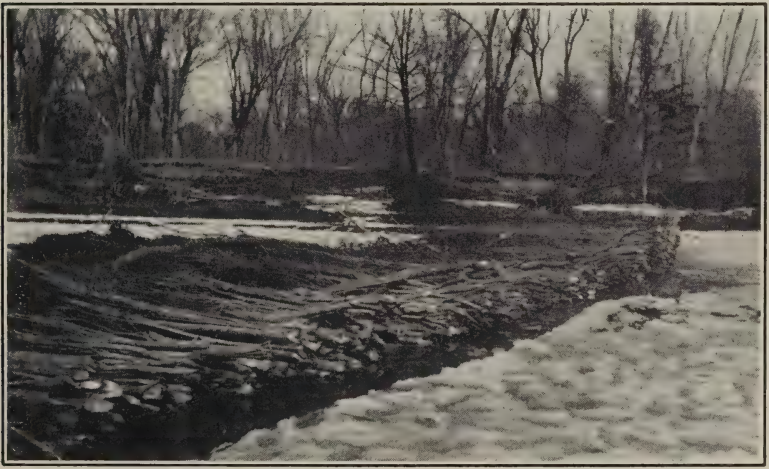


Fig. 5. Willow fascines built into a mat.

In the division *Winona to Wisconsin River,* work was carried on under contract at seven localities at prices ranging from $1.48 to $1.55 per yard for rock and from 36 to 59 cents for brush in place. There were built two closing dams and fifteen wing dams were repaired and raised to a crest elevation of 5 feet. The cost of this work, including all charges, amounted to $1.01 per cubic yard in place, which was considerably cheaper than similar work of 1913 done during the open river season.

In the division *Wisconsin River to LeClaire,* work was done under contract at five localities, at prices ranging from $1.48 to $1.55 for rock and from 42 to 59 cents per cubic yard for brush in place. Fifteen wing dams were built and eight were repaired, at a cost, including all charges, of 80 7-10 cents per cubic yard in place.

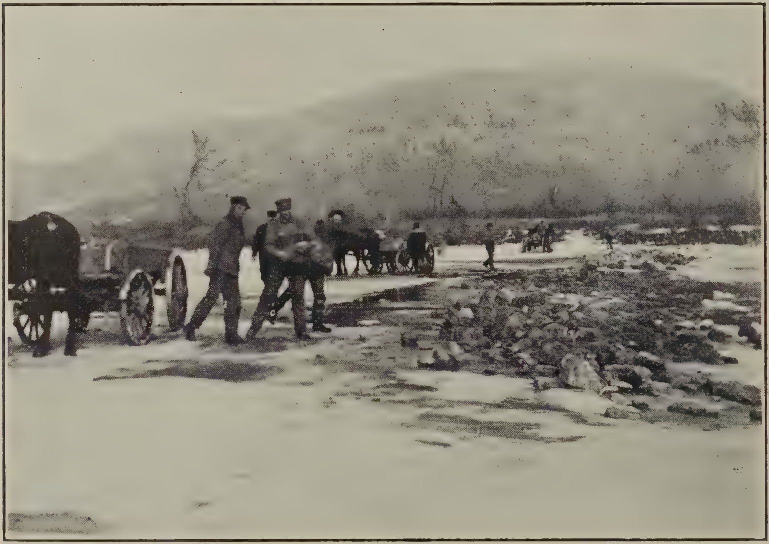


Fig. 6. Winter repairs; ice near dam too thin to permit driving teams close to dam.

The average cost of the entire winter work of the district, involving the placing of 117,565 cubic yards of material, was 92 cents per yard, which is about 7 cents per yard cheaper than the open river work of 1913 done under similar proportions of rock and brush, both by hired labor and contract. There is an indicated saving of about $9,400.

A summary of the winter work of 1914 follows:

Upper Mississippi River Improvement. Summary of Winter Work in January, February, and March, 1914.

Location and designation.	Work began and ended.	Material.			Cost, including inspection.	Average cost per yard.
		Rock.	Brush.	Total.		
Division No. 1, St. Paul to Winona.		*Cubic yards*	*Cubic yards*	*Cubic yards*		
Vicinity of Nininger, 16 dams and shore protections repaired.	January 7 to March 2	4,858.3	----------	4,858.3	$4,712.55	$1.07
Vicinity of Wilds Landing, 11 dams and shore protections repaired.	February 2 to March 2	3,242.9	----------	3,242.9	4,799.49	1.57
Division No. 2, Winona to Wisconsin River.						
Vicinities of Winona, Richmond, Grabhorn Springs, Brownsville, Crosby Slough and Genoa, 2 closing dams built and 15 wing dams repaired.	January 8 to March 9	17,849.1	20,578.1	38,427.2	38,709.44	1.01
Division No. 3, Wisconsin River to LeClaire.						
Vicinities of Guttenberg, Cassville, Waupeton, Dubuque and Bellevue, 15 wing dams built and repaired.	January 5 to March 5	19,477.5	51,559.3	71,036.8	55,762.55	0.81
Totals		45,427.8	72,137.4	117,565.2	$103,984.03	$0.92

Estimated operating cost of work done in vicinity of Guttenberg, Iowa, January, February, and March.

Rock: 7,739.6 cubic yards (for quarrying or gathering, hauling out and piling), at 60 cents per yard		$4 643.76
Brush: 15,984.8 cubic yards (delivered at dam), at 32 cents per yard		5,115.14
Labor:		
1 foreman, 2 months at $150	$300.00	
1 foreman, 2 months at $75	150.00	
28 laborers, 784 days at $1.75	2,205.00	
15 teams and teamsters, 675 days at $3.50	2,362.50	
		$5,017.50
Repairs: To sleds, wagons and tools		200.00
Preliminary: Roads and bridge across slough		400.00
Loss: 3 horses drowned		600.00
Sundries: Estimated		1,597.64
Total		$17,574.04

An average cost of $0.744 per cubic yard.

Paid by Government, $0.873 per cubic yard.

Book Review

TRAINING IN NIGHT MOVEMENTS BASED ON ACTUAL EXPERIENCES IN WAR. Translated from the Japanese by First Lieut. Charles Burnett, Fourth Cavalry. 133 pages. U. S. Cavalry Association. Price, $1.00 postpaid.

The original notes of this little book were prepared by a Japanese officer, who, at the time of the Russo-Japanese War, commanded a company. Their excellence would suggest that the author's name should not be lost to fame, but nowhere can we obtain a clue to his identity. Perhaps it was unknown to the translator.

The guiding principle which the author has in mind might very aptly be summed up by quoting No. 559 Infantry Drill Regulations, U. S. A. ''Offensive and defensive night operations should be practiced frequently in order that troops may learn to cover ground in the dark and arrive at a destination quietly and in good order, and in order to train officers in the necessary preparation and reconnaissance.

''Only simple and well appointed formations should be employed.

''Troops should be thoroughly trained in the necessary details—e. g., night patrolling, night marching, and communication at night.''

The object of night movements is to teach the training of individuals and small units in the ''necessary details'' and to enunciate certain general principles governing night maneuvers by large bodies.

Paragraph 559 quoted above, though containing excellent advice, would seem to be very little, or too little, observed in the American Army. It is feared that both officers and enlisted men consider night exercises ''too much like work.'' During the period of field training and at the biennial maneuvers we occasionally have two or three nights of such exercises, but the grumbling is loud and the movements are of too general a nature to be of much benefit to the individual soldier.

A close perusal of our author's work will disclose the fact that a far different spirit prevails in the Japanese army.

After all, the scientific training of the individual soldier in his war duties is the most important duty of the junior officers of the army. And, it might be added, it is the most irksome. In reading over Night Movements the reviewer was impressed with the idea that a description of the grand maneuvers at Mukden would have been of far more interest to the reader than the detailed accounts of how a squad should be instructed in the duties of night patrol-ing, for instance. Yet the modest Japanese writer enters into a mass of dry but most important details in small matters and leaves the larger affairs to the Oyamas and Kurokis.

Night Movements would form a valuable addition to the libraries of all officers and particularly of company commanders and their lieutenants.

Some of the subjects treated are: Psychological Action at Nighttime, Important Measures Which Correct Unfavorable Psychological Action at Night, How to Dress, Night and Vision, Hearing at Night, Quiet March at Night, Determination of Direction at Night, Night Firing, Night Bayonet Exercise, Training in Night Bayonet Fencing, Night Intrenching, Training in Night Intrenching, Night Demolition Work, Night Sentinels, Night Patrols, Movements of a Detachment at Night, Training in Squad Movements at Night, Squad Night Intrenchments,Method of Training in Night Intrenching, Training and Method of Passing Obstacles at Night, Night Marches and Training, Night Battles.

Of interest to all officers, but especially to engineer officers, will be the author's comments on night intrenching and demolitions and the necessity for instruction in such work in time of peace.

It is refreshing to find that the faith we hold as to night combats is confirmed by the Japanese.

Our articles in the Infantry Drill Regulations and Field Service Regulations agree in every main idea with those of the Japanese.

There are a few typographical errors, but all are small and obvious. In the second paragraph of page 95, the word ''offensive'' is used for ''defensive.''

One is compelled to admire the American officer who has perserverance enough to learn sufficient Japanese to make such a translation as this.—W. W.

A translation by the same author, entitled ''Field Fortifications Based on Practical Experiences of the Russian-Japanese War,'' is reprinted from the *Cavalry Journal* in the present number of the MEMOIRS.

Erratum

In PROFESSIONAL MEMOIRS, No. 26, page 244, third line, instead of ''a ¼-inch spike,'' read ''a 1¼-inch spike.'' The inside diameter of the pipe was 22 inches.

PROFESSIONAL MEMOIRS

Corps of Engineers, United States Army, and Engineer Department at Large

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VOL. VI. NOVEMBER-DECEMBER, 1914. NO. 30

Contents

(*Illustrations in each article are shown by italics.*)

Page.

1. IMPROVING TENNESSEE RIVER ABOVE CHATTANOOGA, TENN., BY REGULATION OR OPEN-CHANNEL METHOD............ 663-691
By Mr. Nicholls W. Bowden, Junior Engineer.
Plan showing direction of current at river bend according to demonstration.. 671
Taken from same source as above. Cross-section at MN, showing direction at river bend 671
*Dipper Dredge "Tellico," casting first cut against bank at Soddy Shoals*L 675
Drill unit at work at Soddy Shoals............................ 677
A close view showing arrangement of steam drills on rafts, working at Soddy Shoals 679
Upper Tennessee River, Little River Shoals...............between.. 680-681
Little River Shoals, condition after final improvement........between.. 680-681
Watts Bar, condition before final improvement...............between.. 682-683
Watts Bar, condition after final improvement...............between.. 682-683
Watts Bar, showing lower works.............................. 683
Kelly Shoals, condition before and after final improvement....between.. 684-685
Kelly Shoals, showing works looking upstream from right bank........ 687
Lyons Shoals, condition before improvement.................between.. 688-689
Williams Shoals, condition before improvement..............between.. 688-689
Approximate cross-section of check, spur, and wing dikes.............. 689
Approximate cross-section of longitudinal dikes...................... 689
Dallas Shoals. Profile showing condition before improvement..between.. 690-691

2. USE AND DEVELOPMENT OF THE PONTON EQUIPAGE IN THE UNITED STATES ARMY, WITH SPECIAL REFERENCE TO THE CIVIL WAR.. 692-758
By Maj. M. J. McDonough and Maj. P. S. Bond, Corps of Engineers.
The Crossing after Antietam 701
Pair of bridges across the Rappahannock at "Franklin's Crossing"...... 709
Canvas bridges across the North Anna.......................... 731
Benham's wharf at Belle Plain................................. 733

3. RECONNOISSANCE EQUIPMENT 759-769
By Maj. W. G. Caples, Corps of Engineers.
Field Sketching Outfit in Container............................ 761
Field Sketching Outfit. Container open and lid up................. 765
Sketcher with table set upon tripod for foot sketching............... 767

4. THE TACTICS OF DIVISIONAL ENGINEERS...................... 770-774
By Lieut. Col. F. E. G. Skey, R. E., Commanding Divisional Engineers, 6th Division.
Reprinted, by permission, from *The Royal Engineers Journal* (Chatham, England), February, 1914.

5. DISCUSSION: MILITARY SURVEY OF OAHU..................... 775-783
By Capt. R. T. Ward, Corps of Engineers.
This article, by Lieut. F. S. Besson, Corps of Engineers, appeared in No. 28 of PROFESSIONAL MEMOIRS.

6. QUINCY ADAMS GILLMORE. (See Frontispiece.).................. 784-785
By First Lieut. F. S. Strong, Jr., Corps of Engineers.

7. EDITORIAL NOTE: PRIZES FOR ARTICLES FOR 1915............ 786

8 SELECTED ARTICLES OF ENGINEERING INTEREST.............. vii-xix
By Mr. Henry E. Haferkorn, Librarian, Engineer School.

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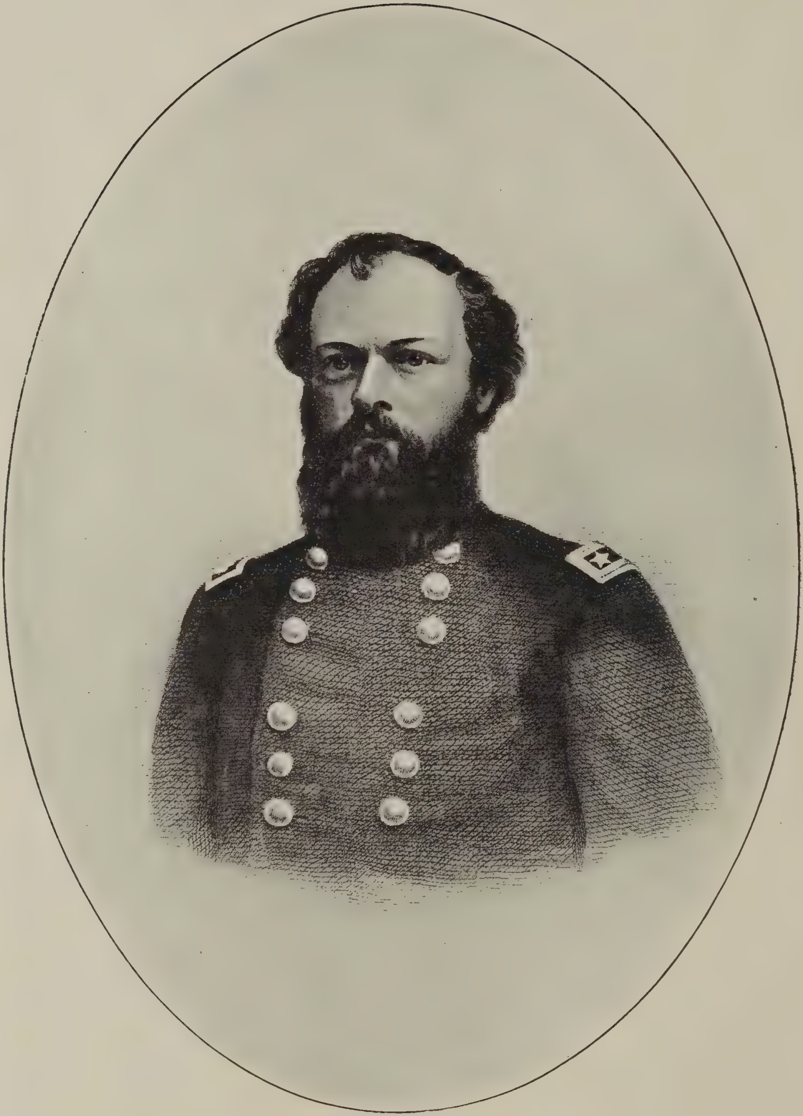

MAJ. GEN. QUINCY ADAMS GILLMORE
CADET, U. S. M. A., 1845-1849

BORN 1825—DIED 1888

SEE PAGE 784

Improving Tennessee River Above Chattanooga, Tenn., by Regulation or Open-Channel Method

BY

Mr. Nicholls W. Bowden
Junior Engineer

INTRODUCTION.

Though it is the writer's purpose to deal primarily with improvements effected during the last five years, since 1909, giving in more or less detail design of works, methods, cost data, results, etc., he deems it advisable to discuss in general the entire 188 mile stretch of the river above Chattanooga, relating the history of previous attempts at improvement and results, believing that this will be of some interest to either the student or casual reader. This, as a preface, will give a better understanding of conditions to be met and tend to emphasize the success of later projects. Nineteen hundred and nine is taken as a starting point for detailed discussion, for the reason that previous to that date there was not a single completed improvement on the Upper Tennessee showing the project channel depth of 3 feet at extreme low water over a channel width of 150 feet and for the reason that it was at about this time that the system of completing the work in full at one shoal before removing plant and force to another obstruction was adopted.

LOCATION.

The locations of the various obstructions to be considered are between a point about 12 miles below the source of the river and a point about 16 miles above Chattanooga, Tenn., thus taking in practically the entire stretch above Chattanooga.

PHYSICAL CHARACTERISTICS.

The source of the Tennessee River is formed by the confluence of the French Broad and Holston rivers in middle east Tennessee, about 4½ miles above Knoxville. It winds its way in a southwesterly direction past Chattanooga, in southeast Tennessee, into northern Alabama. It then changes its course to a northwesterly direction, crossing Alabama and touching northwest Mississippi entering Tennessee again, from which point it flows northerly across west Tennessee, emptying into the Ohio at Paducah in west Kentucky. In its course through east Tennessee, above Chattanooga, the river takes on the following important tributaries: Little Tennessee River, 47 miles below Knoxville; Clinch River, 80 miles below Knoxville; and Hiwassee River, 149 miles below Knoxville.

The catchment basin of the French Broad and Holston rivers has a combined area of about 9,000 square miles, which furnishes to the Tennessee River at its source an extreme low water (about —1.2 feet on Knoxville gauge) discharge of 2,500 cubic feet per second. The entire catchment basin above Chattanooga has an area of about 21,500 square miles, the river proper and tributaries furnishing the additional area. The extreme low water discharge at Chattanooga (0.0 on gauge, previous to increased pool elevation due to back water from Hales Bar) as generally accepted by the Engineer Department is 6,500 cubic feet per second, based on numerous discharge observations.

The average width of the river is about 800 feet at low water, the banks varying in height from 15 to 25 feet, the average being about 20 feet. The banks are very stable, it being found necessary in only a few instances to rip-rap same, and in each case this was due to the channel having been contracted by dikes and the water thrown against that bank. The bed of the stream is very permanent, being composed of gravel, usually cemented, overlying solid rock, which condition makes it very susceptible of improvement either by locks and dams or by the open-channel method. It is true that it is a sediment-bearing stream, but the quantity of material carried in suspension is comparatively small, as evidenced by the fact that a comparison of surveys made years apart does not show any marked changes either on the shoals or in the pools. The average fall over this 188-mile stretch is a little less than 1 foot to the mile (accurately 0.96 foot), but a large portion of this fall is concentrated at the shoals which form only a small per cent of the entire distance. However, at only a few obstructions does the average fall closely approach 5 feet to the mile. From the above, it is easily seen that the problems involved in the improvement of the Upper Tennessee River are not to be compared with those involved in the improvement of rivers such as Mississippi, Ohio, and Missouri, whose banks and beds change from time to time, due to erosion.

HISTORICAL.

In its original condition there were about fifty-five obstructions above Chattanooga, it being difficult to state the exact number owing to the fact that in many cases the line of demarcation between shoals was not very plain, where depths were less than 3 feet at average low water and where slopes and velocities were excessive. As revealed by recent works the material of river bed at these shoals consists of numerous ledges of rock, some bare and others with overlying hardpan, boulders, gravel, and sand. Indeed, in many instances the rock reefs were so close to the surface of the water at low stages that the fall was taken up in a series of well defined steps.

According to our best records these shoals were first attacked in 1832 under state supervision, appropriation of 1830. Under this first appropriation for river improvement, $60,000 was allotted to rivers in east Tennessee; just how much of this amount was expended on the Tennessee is not known. Again, in 1842, the State appropriated $100,000 for improvement of her rivers, but just how much of this was expended on the Tennessee is not known. However, we do know that the appliances and equipment at this time were such that what was accomplished must have been at an abnormal unit cost; that their efforts were directed at the removal of loose boulders from the various channels and the building of wing and spur dikes from stone taken from quarries on the river banks nearby; and that at the present time most of their work has been either moved, modified, or shifted to such an extent that little remains to show for their labor. The improvements effected at that time were, no doubt, commensurate with the needs of navigation and, in justice to their builders, it must be said that the dikes they built withstood the onslaught of ice and drift throughout the years and were in good condition when replaced or shifted in the later years as necessity demanded. Their channel excavation work, while beneficial to the river as a whole, did not lessen to a great extent the work of their successors, the Federal Government, for the reason that as the projects were enlarged to meet the demands of commerce the location of boat channels was changed.

The first project adopted by the United States, made under the direction of the Corps of Topographical Engineers in 1853, proposed a channel depth of 2 feet at low water, to be obtained by excavation and contraction by longitudinal and spur dikes. This project remained in force until the year 1871, when a new project was made calling for a channel depth of 3 feet at low water, to be obtained in the same manner as the previous project. Work was carried on at the worst obstructions along the river until 1893, at which time the estimated cost of 1871 had almost been equaled and much work yet remained to be done. In 1891 a survey was authorized with a view to arriving at a more accurate estimate of the cost of completion of the work begun. This survey was completed in 1893, and the work on the old project continued under the new estimate until 1907, when it was found necessary to revise it again. An Act of Congress approved March 3, 1909, authorized a survey of the entire Tennessee River for the purpose of making plans and estimates of the cost of improving the river, together with recommendations as to just what extent the river was worthy of improvement on its various stretches. This survey, which was made under the direction of Maj. Wm. W. Harts, Corps of Engineers, U. S. A., and accompanying report, were submitted to Congress by the Secretary of War in December, 1911. From this report, by Act of Congress approved July 25, 1912, there was adopted for the Upper Tennessee River a new project, calling for a 3-foot depth at extreme low water (or 4 feet at average low water), to be obtained by open-channel work, supplemented by one lock and dam at Caney Creek Shoals, about 85 miles below Knoxville, suitable for obtaining a 6-foot depth at extreme low water by canalization at a later date should conditions warrant such increased depth. This project, which is the existing one, provides for the expenditure of $1,000,000 on open-channel work, in addition to previous expenditures, and $1,600,000 for the construction of lock and dam at foot of Caney Creek Shoals. It is proposed that appropriations for this work shall be made in sufficiently large sums to permit of the assembling of adequate plant for prosecution of operations at several points simultaneously, in order that the project might be completed within eight years. The initial appropriation of $105,000 in 1912, with an available balance of $46,586.47, and the appropriation of $210,000 in 1913, seem to indicate that it will be possible to carry forward the work as contemplated in making the estimates. It is significant to note, in this connection, that the unit costs of previous improvements have been high and progress slow, due to the smallness of appropriations, which prevented securing the necessary plant for economical construction. Elsewhere in this article it is stated that previous to 1909 the system of completing the work in full at one shoal before removing to another was not followed. By way of explanation, it should be stated that the policy of only partially finishing the project at worst obstructions from time to time was probably actuated by a desire to help conditions in general along the river to subserve the immediate needs of navigation throughout the entire stretch. This policy, while giving an increased depth over a great distance, accounts for the non-completion of any shoal. However, practically all that work will be conserved in planning the final improvement of the shoals, and thus the quantity of work remaining to be done has been greatly lessened.

OBSTRUCTIONS.

In the details to follow the following shoals are to be considered: Little River*, Watts Bar, and Kellys†, which have been completed and Lyons, Williams, and Dallas, the plans for improvement of which have only recently been completed. These shoals present to us probably all the different conditions to be met on the Upper River and afford a study of the different methods used at the present time in effecting improvement under the open-channel system.

PLANS.

Earlier open-channel works on this river, which were carried on under ridiculously small appropriations from year to year, appear to have been the results of a series of experiments by field parties of workmen, who had in mind as their prime purpose the deepening of water at the shoals by the almost exclusive method of contraction, giving little attention to resulting velocities or to channel excavation. The inevitable result was increased depths and oftentimes prohibitive velocities. This condition was aggravated by frequent misplacement of dikes, the location of which had to be changed from time to time and even at the present time much old work must of necessity be shifted or modified in order that full benefit might be derived and that the old work might fit into the new. Considering the difficulties under which the builders of these works labored, which involved the lack of sufficient funds and plant, the lack of modern machinery for excavating purposes, and above all the lack of knowledge concerning the flow of water in open channels, their efforts stand as a monument to their skill. Indeed, at that time it was a much debated question as to whether it was possible to improve a river wholly by regulation; experience in Europe, where this method of improvement has found most extensive application and where results have been most encouraging, having been extremely discouraging at that time. Unfortunately, our predecessors did not observe and record the effects of their various attempts, and we have been forced to look to Europe for information along this line. We now have proof of the feasibility of this method of improvement, on rivers whose axial slope is not too great, whose banks and beds are stable, and whose discharge is sufficiently large, in the completed rivers of Europe as follows: Rhone, Rhine, Weser, Oder, Elbe, Worthe, Vistula, and others. In the case of the Rhone the great slope of 2.5 feet per mile over a stretch of 205 miles was combated and the work successfully completed. However, the high unit cost of nearly $70,000 per mile might have been better spent in canalization.

---

*Only two 30-foot cuts were dredged throughout the length of shoal.

†About seven days will be required to remove several high places in channel.

Engineers have failed in applying this method of improvement on American, as well as foreign rivers, by neglecting to consider the river as a whole in the design of works at one obstruction and by attempting to use this method on sediment-bearing rivers of unstable beds and banks. From these failures we have learned: first, that regulation is best adapted to streams of fixed regimen, and second, that in planning the improvement of a single shoal it is absolutely necessary to take into consideration the effect on shoals immediately above and below. The Rhone presents perhaps the most striking illustration of the above theory. This river is generally classed as one of unstable bed and banks, though neither would be unstable, it is thought, were slopes and velocities not so great. However, a comprehensive plan for its improvement was carried out, only to find upon completion that the shoals were scouring out, the material being deposited elsewhere in the channel and that the water surface was decreasing in elevation at places, due to shifting beds, thus introducing new shoals and making matters worse throughout. After such immense sums had been expended in the previous works, it was considered advisable to evolve some plan to supplement the old, whereby the improvement might be made successful. The plan finally adopted contemplated the preventing of scour of bed by submerged sills, properly spaced, and by the extension of contraction works to equalize and regulate slopes. This improvement was made successful, but at the extremely high cost of nearly $70,000 per mile. In America we point with pride to the results secured by the open-channel method on the Upper Mississippi, perhaps the most extensively improved river in the world, where a low water depth of 4.5 feet has been obtained and maintained and where a recent project contemplates a 6-foot depth throughout. This river is somewhat similar to the Rhone and therefore, in the writer's opinion, does not present the most ideal conditions for this method of improvement. It is a sediment-bearing stream of unstable bed and banks, but of moderate slope. The plans adopted for this river propose contraction works, by spurs from either bank, sufficient to scour out the soft material of beds and to cause the same to be deposited behind the spurs and sufficient to maintain the normal low water surface elevation after this movement has ceased; bank protection by rip-rap stone, and supplemental dredging. The small slope of this section, which is a little less than ½ foot to the mile, is a great advantage for this class of river. There is little doubt but that the cost of maintenance of this improvement will be high. Notwithstanding the above cited successful works under adverse conditions, it is believed that, as previously stated, stability of bed and banks are fundamental requisities for an economical and permanent improvement by regulation.

Returning to the Upper Tennessee, it has been noted from the remarks concerning its physical characteristics that all the requirements for regulation improvement obtain. The earlier works appear not to have followed fixed designs resulting from studies of the varying conditions at different shoals and the application of hydraulic formulæ. As a result unwarranted contractions, with accompanying excessive velocities and extreme slopes, were made at many shoals in the attempt to secure desired depths. At other shoals the full benefit was not secured, owing to the placing of dikes at points that tended to raise the water surface at the head rather than at intermediate places along the shoal. Recently, during the last ten years perhaps, it has been required that detailed plans of the proposed works be prepared before operations are begun and now such plans must be approved by the Chief of Engineers prior to the beginning of work. It was probably this change of policy that led to more study being given this subject.

In the design of works the following are considered fundamental and are given great weight:

(1) Bank channels are better than mid-stream channels, being more easily navigated, especially at night, and ordinarily cheaper of construction, owing to it being practicable to cast the first cut of dredged material against the bank and owing to the necessity of dikes projecting from only one bank.

(2) The outline of works should train the flow of water along the course it has taken rather than force it into a new channel.

(3) The quantity of foreign material, rip-rap stone, etc., placed in the dikes should be reduced to a minimum, rock from channel excavation being used when practicable, thus conforming as closely as possible with the channel which nature has provided.

(4) No channel should be dredged or built across current, as the tendency to fill is accelerated thereby [see (2) above].

(5) When a shoal occurs in a bend of the river the confined channel should be located on the concave side, especially is this imperative when the bed at the locality is composed of gravel and sand instead of rock and where the current is strong. A channel thus located will best maintain itself, as practically all scour will take place along the concave bank. In this connection the following is quoted from William Cawthorne Unwin, the eminent English engineer and writer, in his article in Encyclopedia Britannica, eleventh edition, on ''Hydraulics.''

''*River Bends:* In rivers flowing in alluvial plains the windings which already exist tend to increase in curvature by scouring away of material from the outer bank and the deposition of detritus along the inner bank. Professor James Thompson pointed out that the usual supposition is that the water tending to go forward in a straight line rushes against the outer bank and scours it, at the same time creating deposits at the inner bank. That view is very far from a complete account of the matter and Professor Thompson gave a much more ingenious account of the action at the bend, which he completely confirmed by experiment.''

In the same article Mr. Unwin gives account of the demonstration, evidently that of Professor Thompson of the University of Glasgow, about as follows: ''The tendency of a stream to fill on the convex and scour on the concave side was demonstrated in an

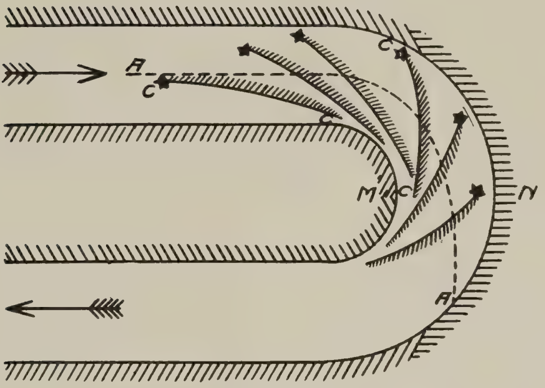

Fig. 1.

Plan showing direction of current at river bend according to demonstration by Professor James Thompson, related by William Cawthorne Unwin in 11th edition Encyclopedia Britannica.

AA shows direction of motion of floating particles. CC shows direction of flow of water immediately in contact with sides and bottom.

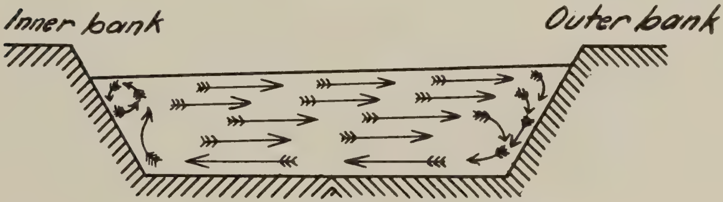

Fig. 2.

Taken from same source as Fig. 1. Cross-section at MN, showing direction of current at river bend.

Arrows show direction of flow from outer or concave bank towards inner or convex bank. Note deposition of detritus at inner bank and increased water surface elevation of concave bank, due to centrifugal force.

artificial stream by means of light seeds and specks of aniline dye, which indicated the action of the surface and sub-surface currents at the bend.'' His conclusions are shown in sketches elsewhere. Vernon Harcourt, another English engineer and writer of great prominence, in his article in the same edition of the Encyclopedia Britannica on ''River Engineering'' says, in effect, the same thing that Mr. Unwin says.

While the bed of the Upper Tennessee is considered stable, gravel and sand does appear and it would seem to be unwise to place a channel along the convex bank unless conditions at the locality in question seem to justify.

Longitudinal vs. Wing or Spur Dikes.

Opinion has been and is still very much divided as to which method of contraction, by wing or by longitudinal dikes, is most efficacious, but it is agreed that effective results can be obtained with either. Wing dikes are more elastic (can be lengthened or shortened economically) and are very valuable on silt-bearing rivers in forming new banks and narrowing the river channel. On the other hand, longitudinal dikes produce a more uniform fall, form a contraction throughout their length, and are considered more suitable for rivers of stable beds. It is always necessary in the use of longitudinal dikes to connect the same at intervals with one bank with ties or cross dikes, and for this reason advocates of the spur dike maintain that it is the cheaper method. It is believed that such is not true, however, in view of the fact that spurs must be placed closer together than cross dikes and must be of heavier construction than longitudinals, in order to withstand the direct head of water and the action of drift against them.

Mathematical Discussion.

When it has been decided to undertake the improvement of a certain shoal on the Upper Tennessee River, the first step taken is to have a detailed survey of the locality made. This survey shows the hydrography of the river and the topography of the banks, including depths to sand, gravel, and bed rock, current velocities, discharge, and any existing dikes. On the same sheet or sheets, upon which the above information is plotted, a profile of this stretch of river is drawn. With this data at hand a mathematical study is begun. The first operation involves the determination of the coefficient C. In this first step we are forced to make use of an empirical formula, and the one which seems to have received the widest acceptance is that of Kutter, which is

$$C = \frac{\frac{1.811}{n} + 41.65 + \frac{0.00281}{S}}{1 + \frac{n}{\sqrt{R}}\left(41.65 + \frac{0.00281}{S}\right)}$$

It is easily seen that the value of C as computed from this formula depends almost wholly upon the values of R and n used in substitution, as the slope enters the numerator and denominator alike. R is a more or less fixed quantity in an improved channel, and in an unimproved channel can be taken, without appreciable error, as the mean depth. Thus n concerns us most. In the absence of the determination of this coefficient by observations, a value of from .025 to .030, depending upon the location of the shoal in question along the 188-mile stretch, has been generally accepted. The writer believes that .030 is more nearly correct for the entire stretch than is .025, but this, of course, is only an opinion.

Having arrived at a value for C, in most cases about 60 with a mean depth of 3 feet, Chezy's formula ($V = C\sqrt{RS}$) is used for computing contracted channel widths and surface slopes.

By substituting for V its equivalent $\frac{Q}{WD}$ in the above formula, we have $\frac{Q}{WD} = C\sqrt{RS}$, or $W = \frac{Q}{C\sqrt{D^3S}}$.

In which:

W=Contracted channel width;
Q=Discharge;
D=Hydraulic radius=mean depth;
S=Surface slope.

On this section of the Tennessee it is desirable that the maximum slope of water surface in an improved channel be not in excess of 8 feet per mile, or .0016, which slope will not produce velocities in excess of 6 feet per second, in order that upstream navigation might not be hindered. With this maximum slope, the average slope on any shoal will be very much flatter.

Maximum velocity or mean velocity is computed from the following formula:

$$V\ (\text{max}) = V\ (\text{mean}) \times \left(1 + \frac{25.4}{C}\right) \quad . \quad . \quad . \quad . \quad (\text{from Bazin}).$$

Though the above formulæ are the result of extended mathematical study, and are the most generally accepted, their practical value in designing works of regulation is greatly lessened by their admitted inexactness and the presence therein of coefficients of wide variation, requiring very careful investigation in the form of survey observations in order to arrive at even approximate values. We are therefore forced to compare theoretic solutions of the problem of channel dimensions with existing successful works, before deciding on the location and length of dikes, in order to get the best results. So far as the writer is informed, no works of this nature have been laid out and completed wholly in accordance with theory.

Elements Affecting Design.

There are two methods of effecting an open-channel improvement, viz, by contraction supplemented by excavation, and by excavation supplemented by contraction. The former contemplates increasing the low water surface elevation as much as practicable and dredging only such material as remains above the required depth. The latter contemplates securing the necessary depths by dredging with sufficient contraction only to maintain the same cross-sectional area of channel and, therefore, the same low water surface elevation. Because of the occurrence of solid rock in such great quantities in the bed of the river, the method of contraction with excavation supplemental has received more extensive application on the Upper Tennessee.

Estimates.

After the plan of improvement has been decided upon, the location of proposed dikes and channel selected and the position of new low water surface calculated, estimates of the cost of carrying out the project, based on the following unit costs, are made:

Rock excavation (including spoil, but not including placing in dikes) at $2.00 per cubic yard, place measurement.

Gravel excavation (including spoil) at 20 cents per cubic yard, place measurement.

Placing excavated rock in dikes at 75 cents per cubic yard, place measurement.

Quarrying, towing, and placing rock in dikes at $1.50 per cubic yard, loose measurement.

To this total, 20 per cent is added for engineering and con-

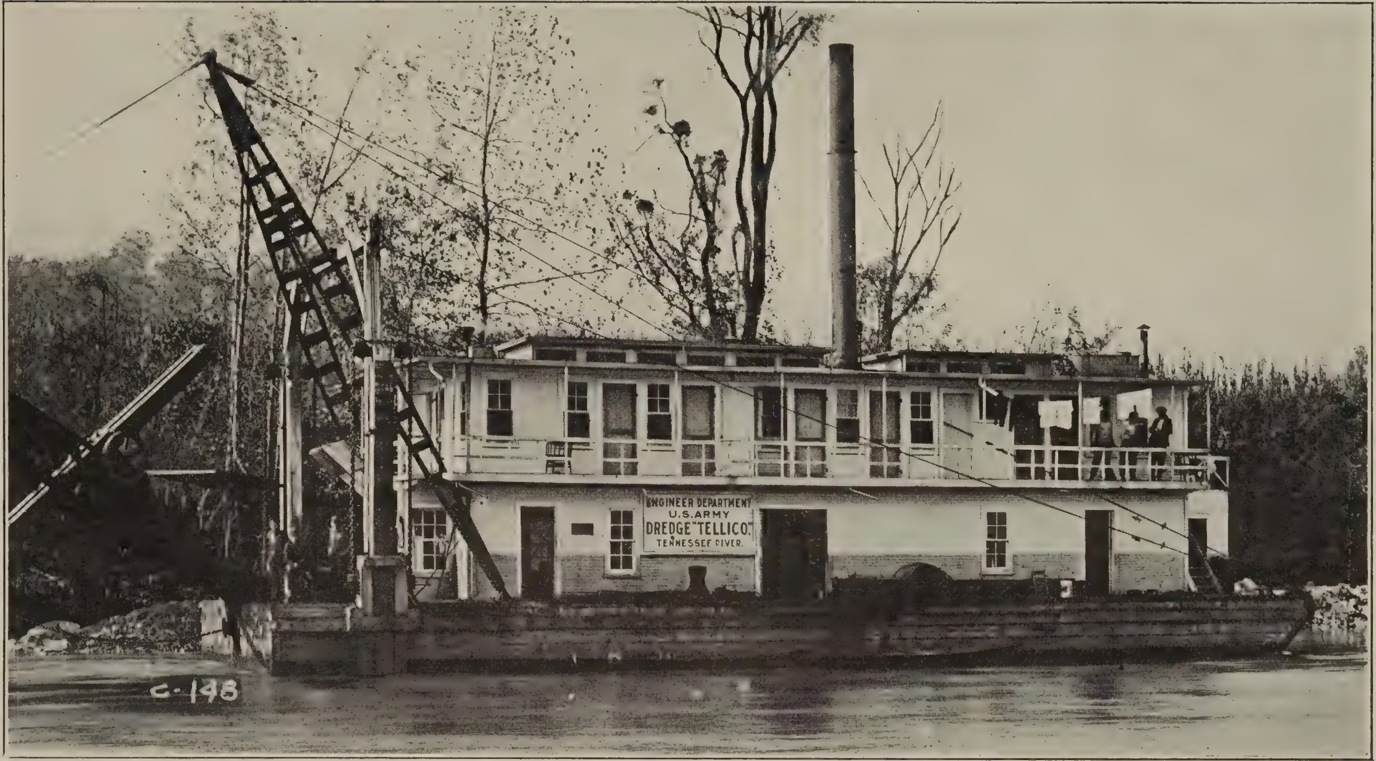
ENGINEER DEPARTMENT
U.S.ARMY
DREDGE "TELLICO"
TENNESSEE RIVER.
C-148

Fig. 3. 1½ cubic yard dipper dredge *Tellico*, casting first cut against bank at Soddy Shoals in November, 1913.

tingencies. These unit costs are based on actual costs on this river during recent years, under practically the same conditions as will obtain for several years. Inasmuch as unit costs have been reduced about 50 per cent during the last fifteen or twenty years, it seems that another reduction will have to be made in the near future in making estimates.

CONSTRUCTION.

After the plans and estimates have been completed, following the above procedure, and approved, the work of construction is begun. Owing to the prevalence of high stages of the river, precluding the active prosecution of improvement work, during the period January to May, inclusive, it is absolutely necessary that the speed of operations be kept at a maximum during the working season. With that purpose in view, a great deal of study has been given to the selection of efficient floating plant, organization, etc., which has resulted in an increase in amount of work done with corresponding decrease in unit costs. At the present time there are two complete working units engaged above Chattanooga, and it is expected to add another by January 1, 1915. The complement of floating pieces attached to each unit at the beginning of the 1914 working season was as follows:

1 1½ cubic yard non-propelling dipper dredge; size of hull, 80 by 30 by 7 feet.
1 stern-wheel towboat; size of hull, 100 by 20 by 4 feet.
3 derrick-boats equipped with orange-peel and clam-shell buckets, 65-foot booms; size of hulls, 80 by 30 by 4 feet.
1 drill tender (same as derrick-boat with increased boiler power); size of hull, 80 by 30 by 4 feet.
3 drill rafts, size 30 by 16 feet by 1 foot, equipped with two steam drills each.
2 slope deck dump scows, four pockets to each side; size of hull, 73 by 20 by 6 feet.
1 coal barge, flat deck; size, 100 by 24 by 5 feet.
8 stone barges, flat deck; size, 80 by 20 by 4 feet.
1 tool boat; size, 65 by 16 by 3 feet.
2 quarter-boats, 1 2-story and 1 single-story, with quarters and mess for about 125 men. Launches and skiffs, etc., for dispatch work.

Each unit of the above proportions will complete the improvement of an average shoal during one working season at an expenditure of about $50,000, including overhead and deterioration charges.

As the construction work at a shoal progresses, the effect on

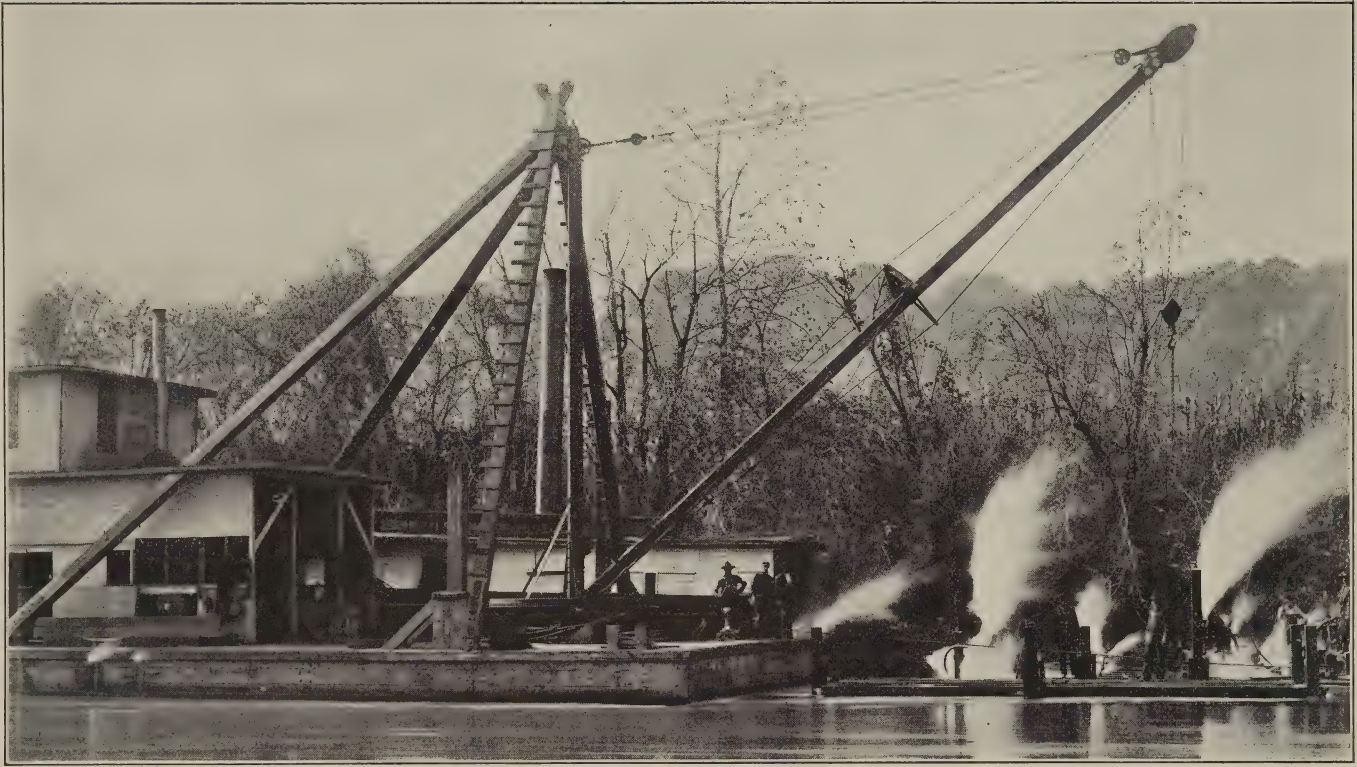

Fig. 4. Showing drill unit at work at Soddy Shoals during November, 1913.

current velocities and water surfaces is noted daily, gauges having been established prior to the beginning of operations. These daily observations often reveal the necessity of slightly modifying the plans as to the exact location or length of dikes, and by so doing a better improvement is secured. With the present knowledge of the flow of water in open channels it is not believed to be feasible to follow in detail any fixed plans for the improvement at an obstruction, but expedient, in order to obtain the best results, to take advantage of every opportunity in the field to improve those plans, thereby adding to our knowledge of the subject.

Methods.

In prosecuting open-channel improvements there are three separate classes of work; namely, excavating rock, excavating gravel, and building dikes. In order to excavate solid or hard rock from the channel it is, of course, necessary first to dislodge it from its bed and then to remove it in loose form. The first process, that of drilling and blasting, has proven the expensive operation in the removal of subaqueous rock, and has therefore received much study under varying conditions. This has resulted in the use of various types of drill boats, tenders, and rafts. Because of the shallow depths and high current velocities in which drilling operations are carried on, a drill raft, constructed of heavy timbers spaced 15 feet apart longitudinally and 2 feet crosswise, supported by spuds, has been found most advantageous on the Upper Tennessee work. The steam drill tripod legs are fastened to wooden A-frames which are, in turn, clamped to the timbers of raft. Each raft, size 30 by 16 feet, is equipped with two drills forming one-third of the drill unit, three rafts and six drills being used. This battery of drills is supplied with steam from a drill tender, lashed alongside, which is equipped with a steam derrick for moving drills from place to place on the rafts. When the area covered by rafts has been ''drilled out,'' the holes are loaded with explosives and the rafts lifted from over the charged area before the shot is fired. The blasted rock is removed from channel by dipper, clam-shell, or orange-peel dredge and loaded on barges for use in dikes. The barges of rock are unloaded at the dikes by derrick-boats handling clam-shell and orange-peel buckets. In the event that the blasted material does not contain ''spalls'' sufficient in quantity to fill the voids of the larger dike stones (one-man size), gravel or quarried rock is used for that purpose. Rock excavation has

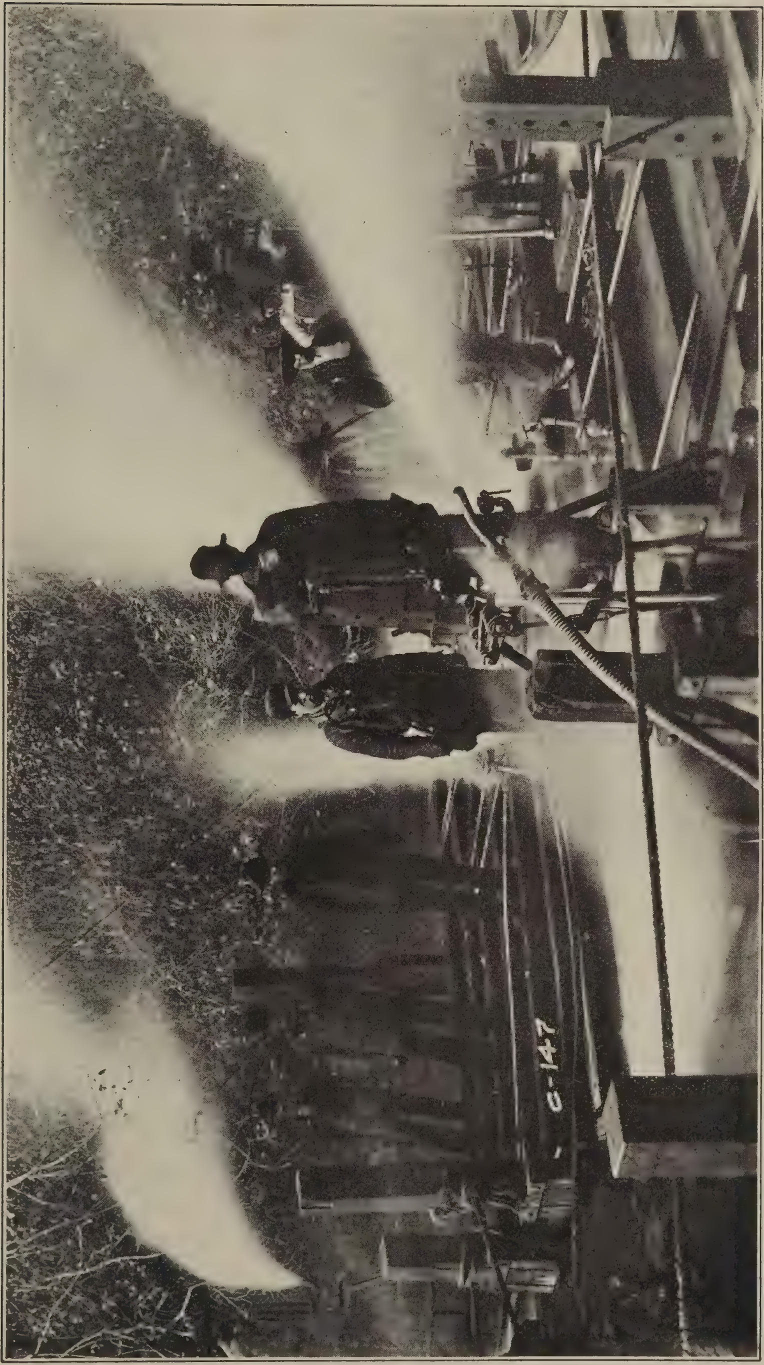

Fig. 5. A close view showing arrangement of steam drills on rafts, working at Soddy Shoals during November, 1913.

been found to be the most expensive class of open-channel work and for that reason every effort is made in planning improvements to reduce the quantity of that material for removal to a minimum.

Gravel excavation is accomplished almost exclusively by dipper dredges, working downstream and kept on straight courses by ranges either ahead or behind. Ordinarily, improvements are laid out in such a way as will permit of the first cut being cast. The material from second, third, fourth, and fifth cuts, each 30 feet wide (the width of dredged channel being 150 feet) is loaded on dump scows, which are towed to deep water and dumped. This class of work is the fastest and cheapest of any. The third distinct class of work, dike building, generally requires the use of a rock quarry, though in some cases it is possible to secure sufficient excavated material to build the necessary dikes. The abundance of limestone rock bluffs along the banks of this section of the river makes the securing of foreign dike material very easy. These bluffs are found at intervals of 3 or 4 miles, and it is always possible to secure a quarry with the water surface as a boundary of the yard. This condition eliminates the cableway, tramway, etc., necessary in moving quarried stone from yard to river bank when a suitable quarry can not be had at the water's edge. The method of quarrying rock for these dikes is very similar to methods used elsewhere, in that steam drills and explosives are used for dislodging material and throwing it into the yard below. Jackhammer drills and sledge-hammers are used for breaking the larger stones to desirable sizes. Very few pieces larger than ''two-man'' size are placed in dikes, as it has been found that the smaller stones resist the action of drift and broken rafts of logs better. However, in deep water large boulders are often used in the foundation of dikes. A steam derrick, erected at a convenient point in the quarry, is used for loading the stone on flat-deck barges. This is done by means of skips or scale boards, which are loaded by hand in the quarry and dumped with a trip on the barge. The loaded barge is unloaded at the dike by clam-shell or orange-peel bucket operated by floating steam derrick, the scattered pieces which the bucket will not pick up being handled by hand. Where the length of tow from quarry to dike is not great, this class of work progresses fast and is cheaper than excavating and placing channel rock in dikes, except, of course, where the excavation must be made in order to secure channel.

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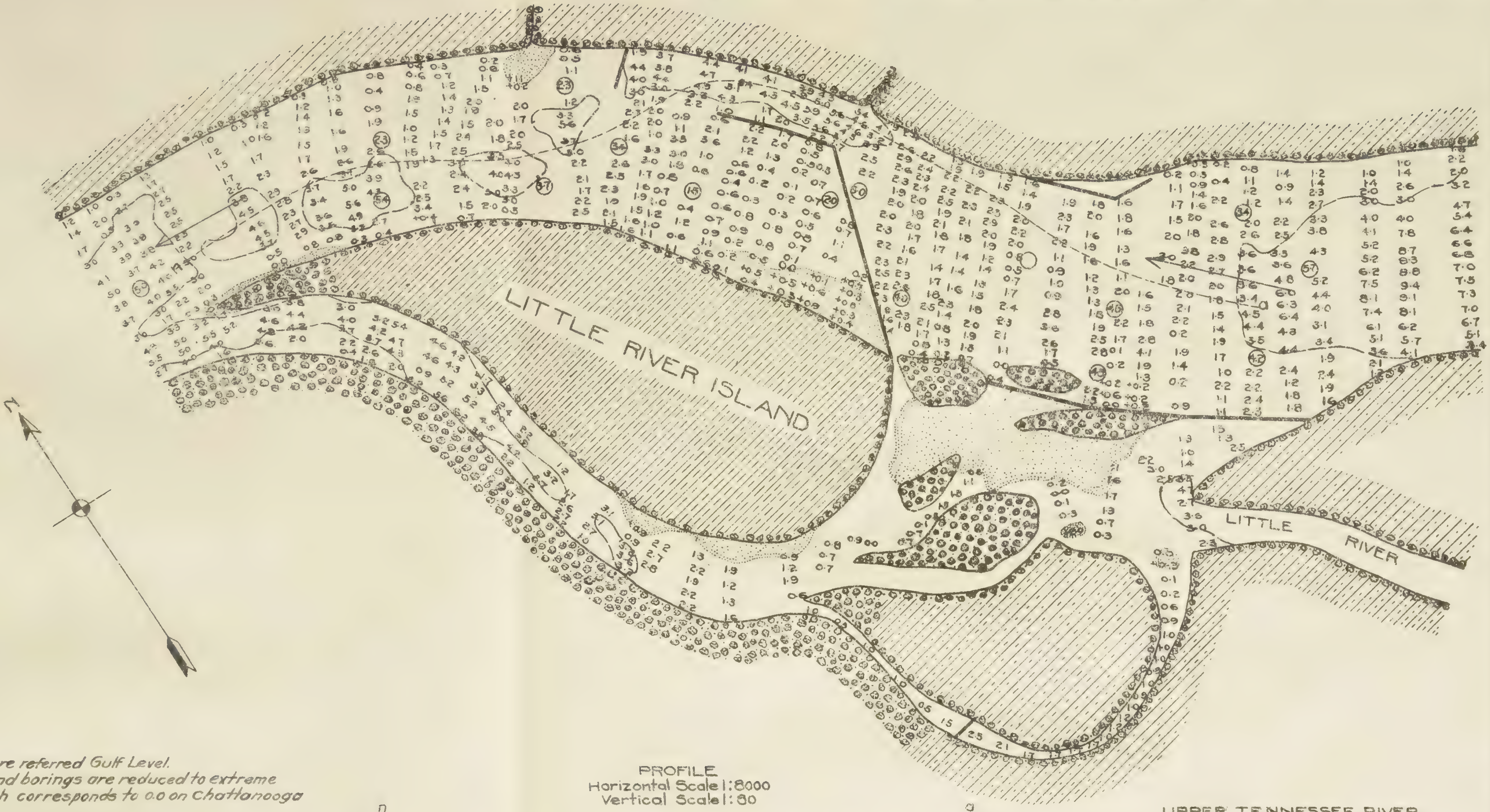


NOTE:

Elevations are referred Gulf Level.

Soundings and borings are reduced to extreme low water which corresponds to 0.0 on Chattanooga gage.

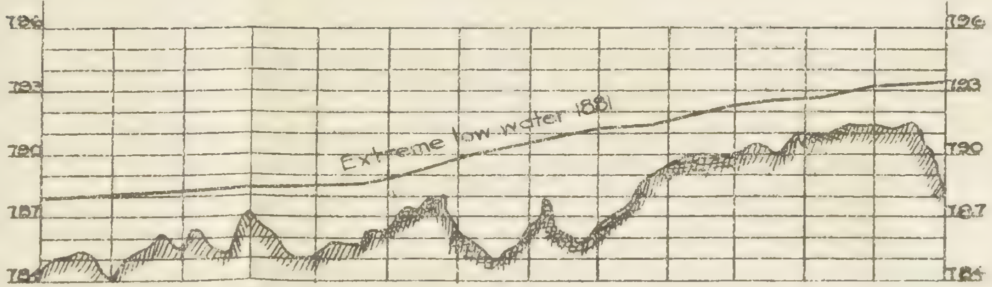
Under water contour is 3' below low water and is shown thus:— — — —

Profile is along dotted line or line of present channel.

Numbers within circles indicate depth to rock below low water.

Existing dikes are shown thus:———

PROFILE
Horizontal Scale 1:8000
Vertical Scale 1:80

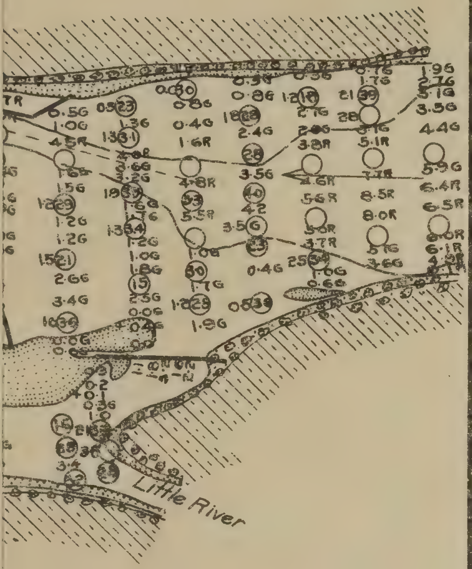


UPPER TENNESSEE RIVER

LITTLE RIVER SHOALS

Surveyed under the direction of
LIEUT. COL. HENRY M. ROBERT
Corps of Engineers, U.S.A.
by
1st. LIEUT. JOHN BIDDLE
Corps of Engineers, U.S.A.
MAY to NOVEMBER 1891
Scale 1: 4000
400 200 0 200 400

Reduced + Traced by E.F.S.

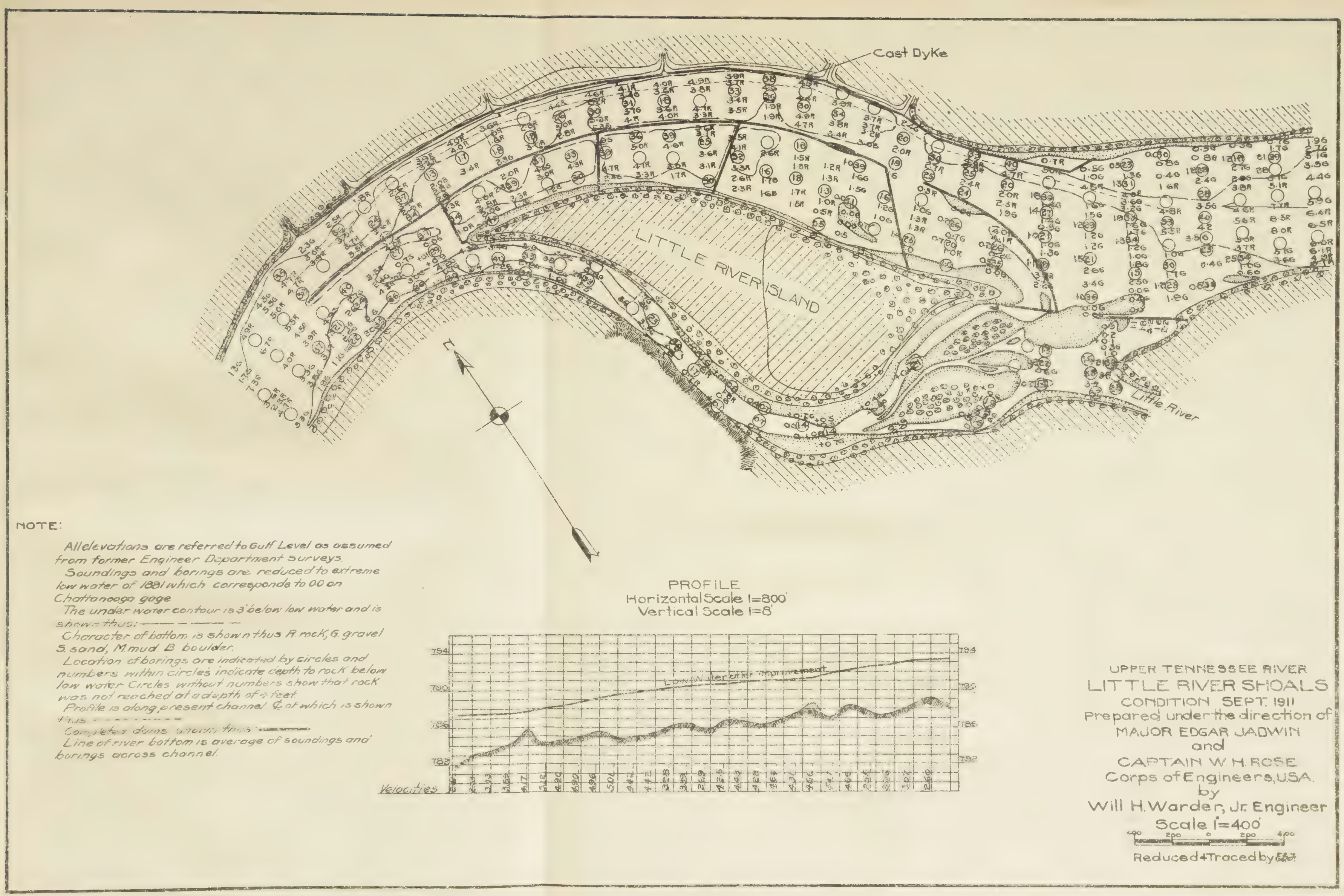


UPPER TENNESSEE RIVER

LITTLE RIVER SHOALS

CONDITION SEPT. 1911
Prepared under the direction of
MAJOR EDGAR JADWIN
and
CAPTAIN W. H. ROSE
Corps of Engineers, U.S.A.
by
Will H. Warder, Jr. Engineer
Scale 1" = 400'
400 200 0 200 400

Reduced + Traced by E&T.


Cast DyKe
LITTLE RIVER ISLAND
Little River
PROFILE
Horizontal Scale 1=800'
Vertical Scale 1=8'
794
790
786
782
Low water after improvement
Velocities
Scale 1"=400'
400
200
0
200
400

NOTE:

All elevations are referred to Gulf Level as assumed from former Engineer Department surveys.

Soundings and borings are reduced to extreme low water of 1881 which corresponds to 0.0 on Chattanooga gage

The under water contour is 3' below low water and is shown thus: ——— — ——— —

Character of bottom is shown thus R. rock, G. gravel S. sand, M. mud. B. boulder.

Location of borings are indicated by circles and numbers within circles indicate depth to rock below low water Circles without numbers show that rock was not reached at a depth of 4 feet.

Profile is along present channel ℄ of which is shown thus - - - - - - - -

Completed dams shown thus ———

Line of river bottom is average of soundings and borings across channel.

UPPER TENNESSEE RIVER
LITTLE RIVER SHOALS
CONDITION SEPT. 1911
Prepared under the direction of
MAJOR EDGAR JADWIN
and
CAPTAIN W. H. ROSE
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by
Will H. Warder, Jr. Engineer
Scale 1"=400'
Reduced + Traced by E.&T.

Fig. 7. Little River Shoals, condition 1911 after final improvement.

LITTLE RIVER SHOALS.

Though Little River Shoals was the worst obstruction above Chattanooga, it appears that its improvement by the General Government was overlooked until the year 1881, when some little work was done, the exact nature of which is unknown. In 1882 further work was done, resulting in an increase of 10 inches in the average depth over the shoal. Although it is not specifically stated in the reports, it is believed that the operations during these two years were confined to the removal of loose surface obstructions and to the building of a spur dike, extending from the right bank about 100 feet into the river from a point about 1,500 feet below the head of the shoals, and closing dike at the head of Little River Island. An existing wing dike extending from above the head of Little River Island was probably the result of state work. While increasing the available depth, this work did not remedy the excessive slopes and current velocities and later it became evident that a comprehensive scheme for improving the shoal throughout its length must be devised. In 1908, when the final improvement was begun, the channel was very crooked and treacherous, the fall between head and foot of shoal, a distance of 6,000 feet, being nearly 6 feet, with a maximum of about 15 feet per mile and a corresponding maximum current velocity at mid-depth of about 9 feet per second. The average depth in the channel was about 2 feet at low water. It was evident from a study of the above conditions, that the improvement plan should provide for the flattening of slopes as well as for increasing depths. The plan evolved proposed a longitudinal dike to join to the wing dike at the head of Little River Island, to extend downstream to a point about 1,000 feet below foot of island with cross dikes to tie same to island at suitable intervals. This dike was to contract the channel to 275 feet at its narrowest point, and supplemental dredging along the right bank was to finish the improvement. Unfortunately, no maps of surveys of this location prior to 1882, showing the profile of water surface, exist, and it is therefore impossible to note the full effect of the contraction, inasmuch as contraction by a wing dike was made prior to 1881. However, the benefit of contraction in the flattening of slopes and reduction of current velocities can be noted by examining Figs. 6 and 7, presented with this article. The maximum slope of 15 feet per mile was reduced to 12 feet per mile and the maximum current velocity of 9 feet per second was reduced to 5.47 feet per second. The average depth was increased from 2 feet to 3 feet at low water over a channel width of 60 feet, operations having been discontinued in 1910 without making the proposed five 30-foot cuts.

The success achieved in applying the open-channel method at this, the worst shoal on this stretch of river, has been very encouraging, but it is extremely unfortunate that the full channel width was not excavated in order that the effect on the elevated water surface might have been noted, as there is still room for doubt as to the possibility of maintaining a raised water surface after the 150-foot channel section has been excavated.

Total and Unit Costs at Little River Shoals, 1908-1910.

	Quantities. Cubic yards.	Linear feet.	Total cost.	Unit cost.
Rock excavation	*65,177		$27,341.48	$0.419
Dike construction		6,081	11,452.55	1.883
Total			†$38,794.03	

*Estimated loose measurement; includes hardpan.

†Field cost; does not include overhead or depreciation charges.

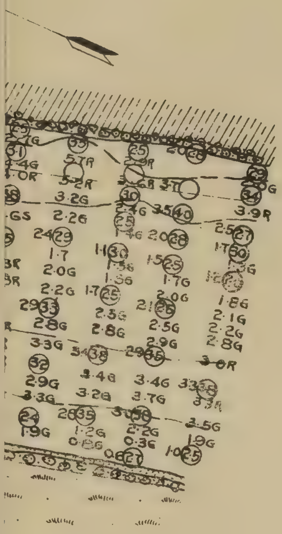
Drilling and Blasting Costs at Little River Shoals, 1908-1910.

Number holes.	Linear feet.	Depth of water over rock.	Area blasted. Square feet.	Cost.	Unit cost. Linear foot.
2,296	11,934	3′	185,824	*$7,301.68	$0.612

*Field cost.

WATTS BAR.

The improvement of Watts Bar, 66 miles above Chattanooga, was first undertaken by the General Government in 1872 and was continued during the succeeding years of 1873 and 1874. During this period only minor work, consisting of excavating loose rock and a narrow solid rock reef and building a wing dike about 1,000 feet long was done. No work was done between 1874 and 1911, when the final work was started. As at Little River Shoals, early maps showing condition before first improvement are lacking. A survey in 1911 showed an average depth of about 2 feet, a maximum slope of about 12 feet per mile, and a maximum current velocity of 5.70 f. s. Active operations at this locality were prosecuted during the two working seasons of 1911-'12, the full project being completed. In this case, unlike Little River Shoals, the full



UPPER TENNESSEE RIVER

WATTS BAR

CONDITION AUGUST 1911
Surveyed under the direction of
MAJOR G.A.F. FLAGLER
Corps of Engineers, U.S.A.
WILL H. WARDER, Jr. Engineer
Scale 1"=400'

Drawn by S.A.W.
Checked by W.H.W.
Reduced & Traced by E.S.J.

sheet 1.

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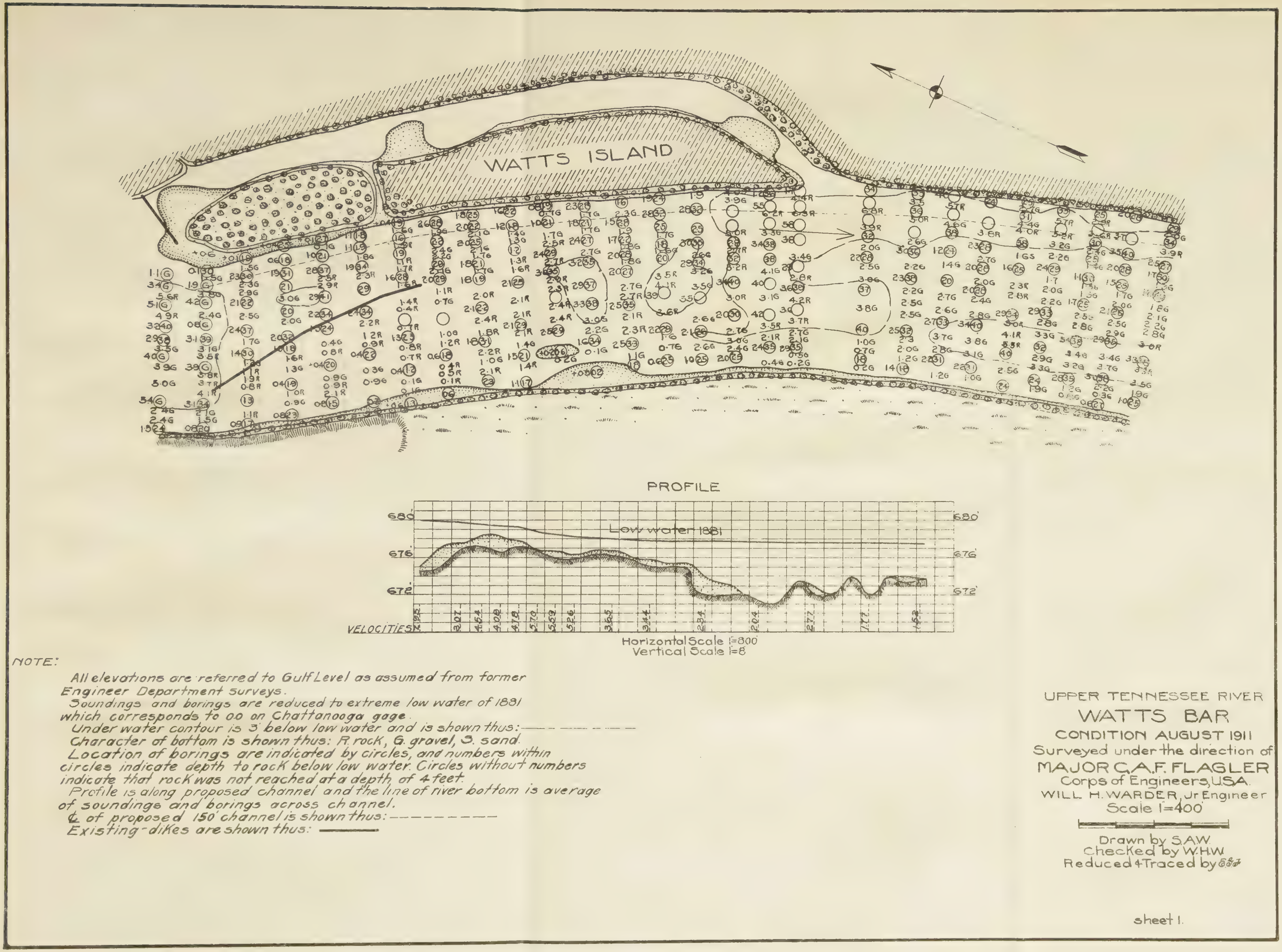

WATTS ISLAND
PROFILE
680
676
672
680'
676'
672'
Low water 1881
VELOCITIES
Horizontal Scale 1"=800'
Vertical Scale 1"=8'

NOTE:

All elevations are referred to Gulf Level as assumed from former Engineer Department surveys.

Soundings and borings are reduced to extreme low water of 1881 which corresponds to 0.0 on Chattanooga gage.

Under water contour is 3' below low water and is shown thus: — — — — — —

Character of bottom is shown thus: R. rock, G. gravel, S. sand.

Location of borings are indicated by circles, and numbers within circles indicate depth to rock below low water. Circles without numbers indicate that rock was not reached at a depth of 4 feet.

Profile is along proposed channel and the line of river bottom is average of soundings and borings across channel.

℄ of proposed 150' channel is shown thus: - - - - - - - - -

Existing-dikes are shown thus: ———

UPPER TENNESSEE RIVER

WATTS BAR

CONDITION AUGUST 1911

Surveyed under the direction of

MAJOR C.A.F. FLAGLER

Corps of Engineers, U.S.A.

WILL H. WARDER, Jr Engineer

Scale 1"=400'

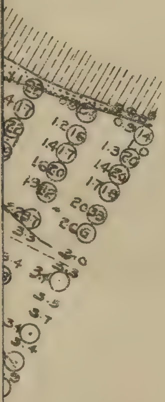
Drawn by S.A.W.

Checked by W.H.W.

Reduced & Traced by G.S.J.

sheet 1.

Fig. 8. Watts Bar, condition 1911 before final improvement (sheet No. 1).



UPPER TENNESSEE RIVER

WATTS BAR

CONDITION AUGUST 1911
Surveyed under the direction of
MAJOR C.A.F. FLAGLER
Corps of Engineers, U.S.A.
WILL H. WARDER, Jr. Engineer
Scale 1"=400'
400 200 0 200 400

Drawn by S.A.W.
Checked by W.H.W.
Reduced+Traced by [illegible]

Sheet 2.

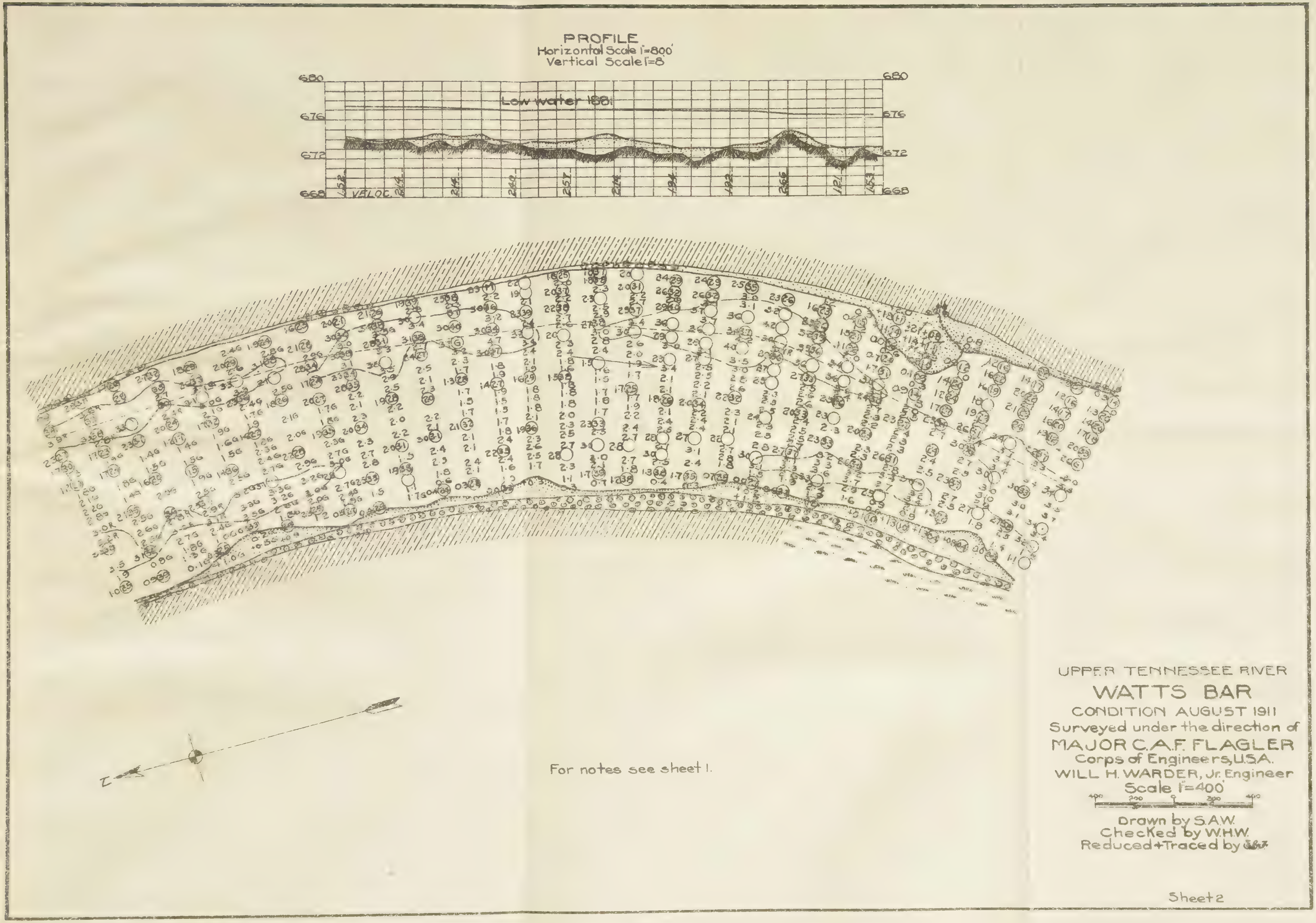
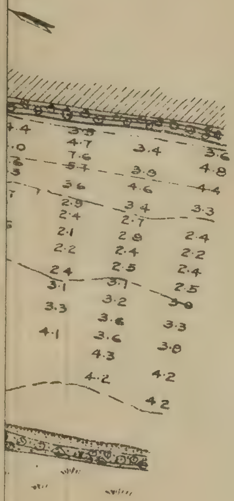

PROFILE
Horizontal Scale 1"=800'
Vertical Scale 1"=8'
680
676
672
668
Low water 1881
VELOC.
UPPER TENNESSEE RIVER
WATTS BAR
CONDITION AUGUST 1911
Surveyed under the direction of
MAJOR C.A.F. FLAGLER
Corps of Engineers, U.S.A.
WILL H. WARDER, Jr. Engineer
Scale 1"=400'
400 200 0 200 400
Drawn by S.A.W.
Checked by W.H.W.
Reduced + Traced by
For notes see sheet 1.
N
Sheet 2

Fig. 9. Watts Bar, condition 1911 before final improvement (sheet No. 2).


4.4
3.3
4.7
7.6
5.7
3.4
3.6
3.9
4.8
3.6
4.6
4.4
2.9
3.4
3.3
2.4
2.7
2.1
2.8
2.4
2.2
2.4
2.2
2.4
2.5
2.4
3.1
3.7
2.5
3.9
3.3
3.2
3.6
3.3
4.1
3.6
3.8
4.3
4.2
4.2
4.2

UPPER TENNESSEE RIVER

WATTS BAR

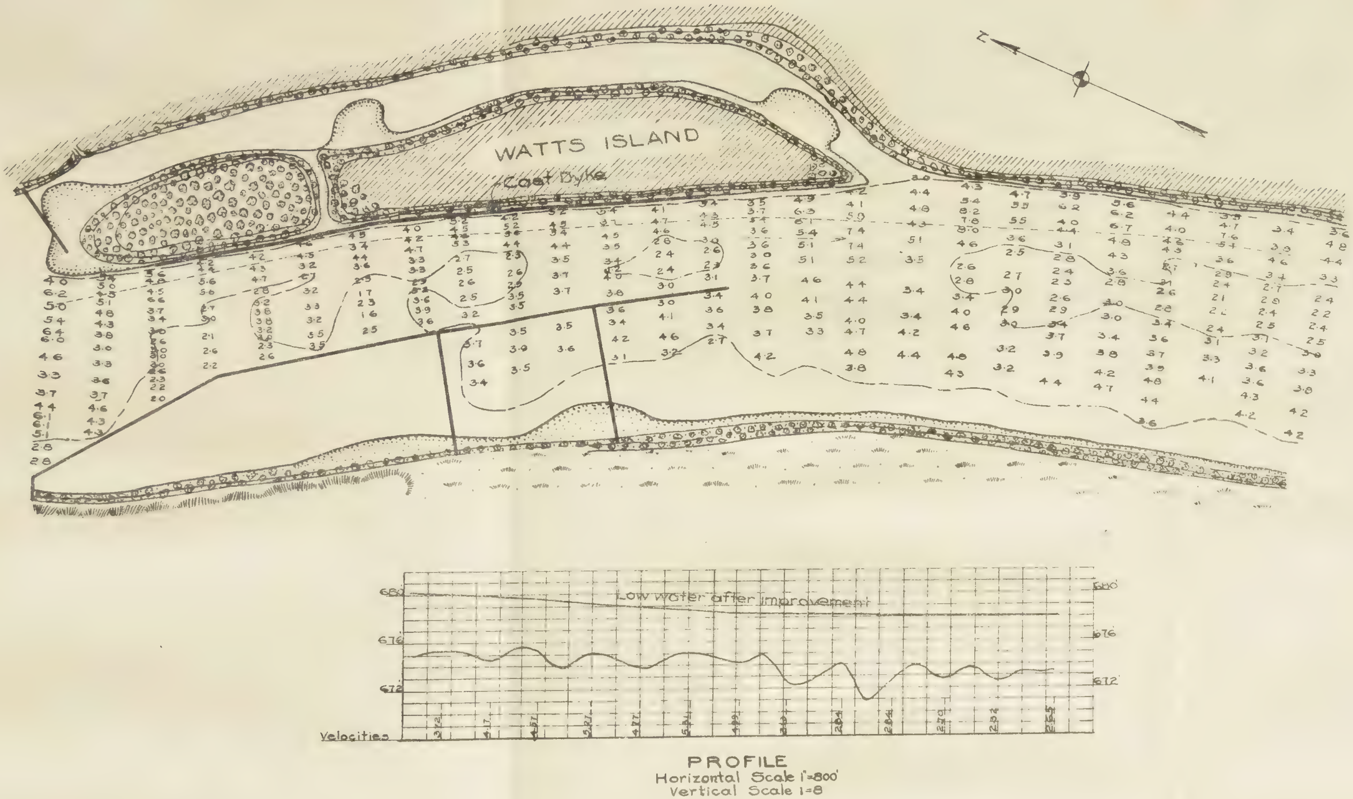
CONDITION JULY, 1913
Prepared under the direction of
MAJOR H. BURGESS
and
CAPTAIN R.C.MOORE
Corps of Engineers, U.S.A.
by
Edward G. Freiler, Surveyor

Scale 1" = 400'

400 200 0 200 400

Drawn by E.G.F.
Traced by E.G.F.

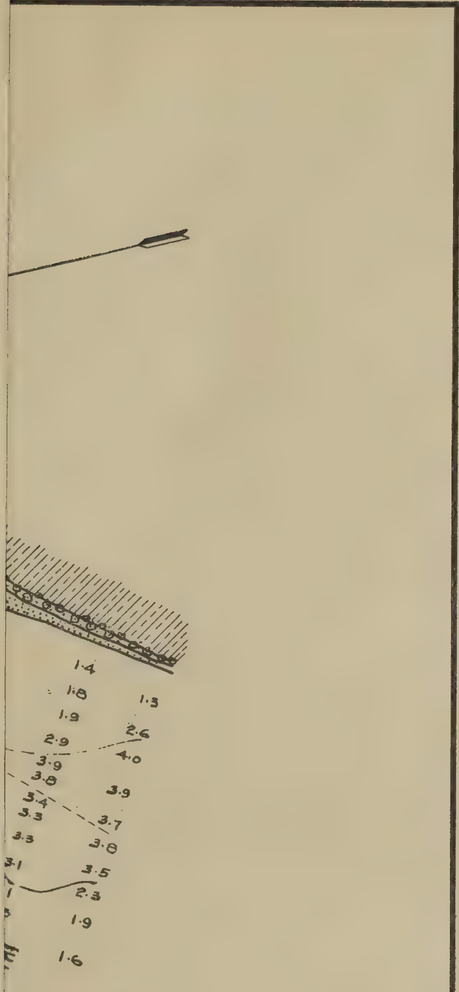
Sheet 1.


WATTS ISLAND
Coat Dyke
N
680
676
672
Low water after improvement
Velocities
3.72
4.17
4.51
5.27
4.77
5.81
4.99
2.84
2.84
2.70
2.32
2.55
PROFILE
Horizontal Scale 1"=800'
Vertical Scale 1=8

NOTE:
All elevations are referred to Gulf Level as assumed from former Engineer Department Surveys
Soundings are reduced to extreme low water of 1881 which corresponds to 0.0 on Chattanooga gage
Profile is along channel, ℄ of which is shown thus: - - - - - - - -
Completed dykes are shown thus: ———
The under water contour is 3' below low water and is shown thus: —— – —— – ——

UPPER TENNESSEE RIVER
WATTS BAR
CONDITION JULY, 1913
Prepared under the direction of
MAJOR H. BURGESS
and
CAPTAIN R.C.MOORE
Corps of Engineers, U.S.A.
by
Edward G. Freiler, Surveyor
Scale 1"= 400'
400 200 0 200 400
Drawn by E.G.F.
Traced by E.G.F.
Sheet 1.

Fig. 10. Watts Bar, condition 1913 after final improvement (sheet No. 1).


1.4
1.8
1.3
1.9
2.9
2.6
3.9
4.0
3.8
3.9
3.4
3.3
3.7
3.3
3.8
3.1
3.5
2.3
1.9
1.6

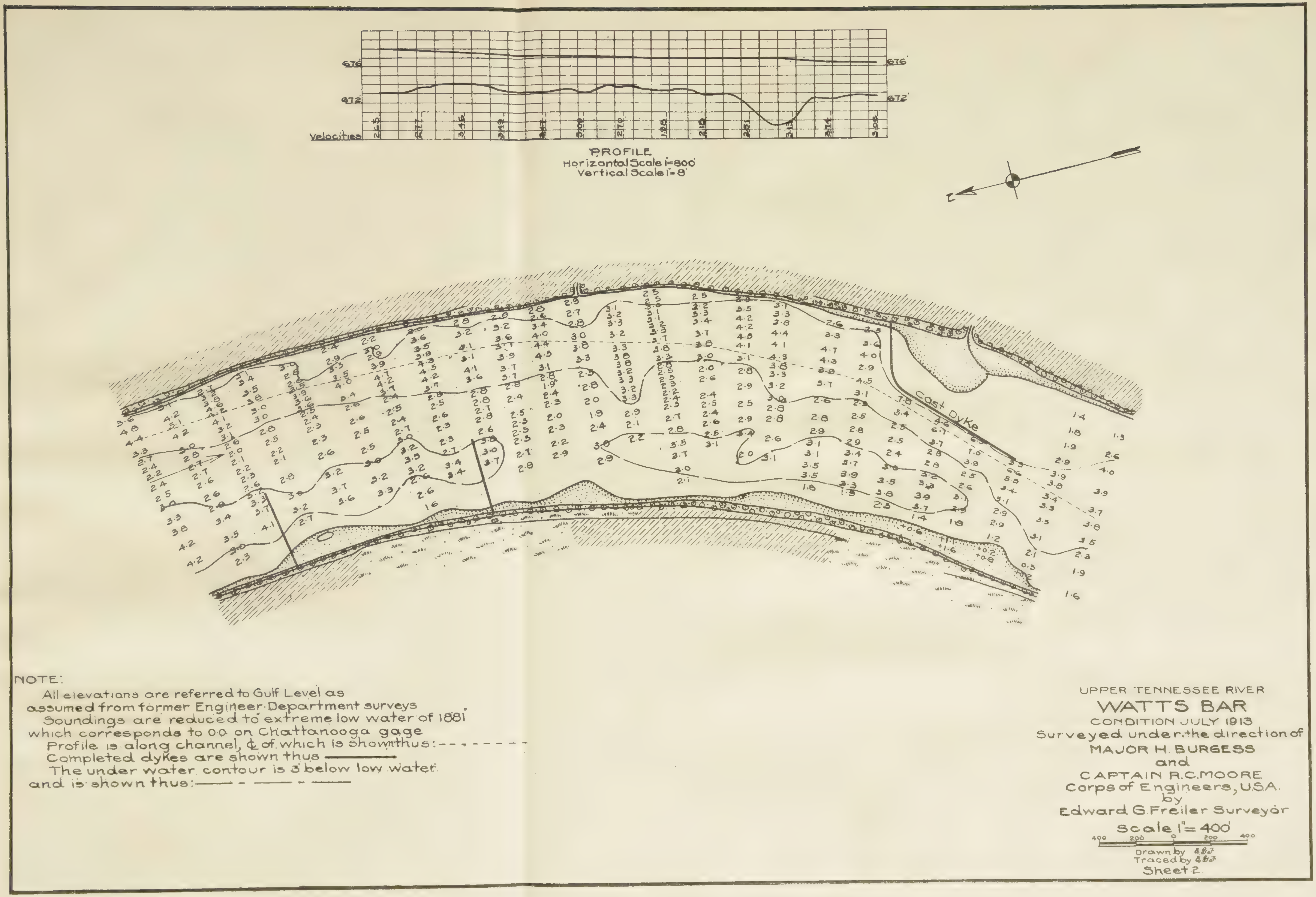
UPPER TENNESSEE RIVER

WATTS BAR

CONDITION JULY 1913
Surveyed under the direction of
MAJOR H. BURGESS
and
CAPTAIN R.C. MOORE
Corps of Engineers, U.S.A.
by
Edward G. Freiler Surveyor

Scale 1" = 400'
400 200 0 200 400

Drawn by E.G.F.
Traced by E.G.F.
Sheet 2.


676'
672'
676'
672'
Velocities
2.65
2.77
3.46
3.42
3.47
3.09
2.70
1.28
2.12
2.51
3.13
3.14
3.06
PROFILE
Horizontal Scale 1"=800'
Vertical Scale 1"=8'
Cast Dyke
400
200
0
200
400

NOTE:
All elevations are referred to Gulf Level as assumed from former Engineer Department surveys
Soundings are reduced to extreme low water of 1881 which corresponds to 0.0 on Chattanooga gage
Profile is along channel, ℄ of which is shown thus: - - - - - - - -
Completed dykes are shown thus ————
The under water contour is 3' below low water and is shown thus: —— - —— - ——

UPPER TENNESSEE RIVER
WATTS BAR
CONDITION JULY 1913
Surveyed under the direction of
MAJOR H. BURGESS
and
CAPTAIN R.C. MOORE
Corps of Engineers, U.S.A.
by
Edward G. Freiler Surveyor
Scale 1"= 400'
Drawn by E.G.F.
Traced by E.G.F.
Sheet 2.

Fig. 11. Watts Bar, condition 1913 after final improvement (sheet No. 2).

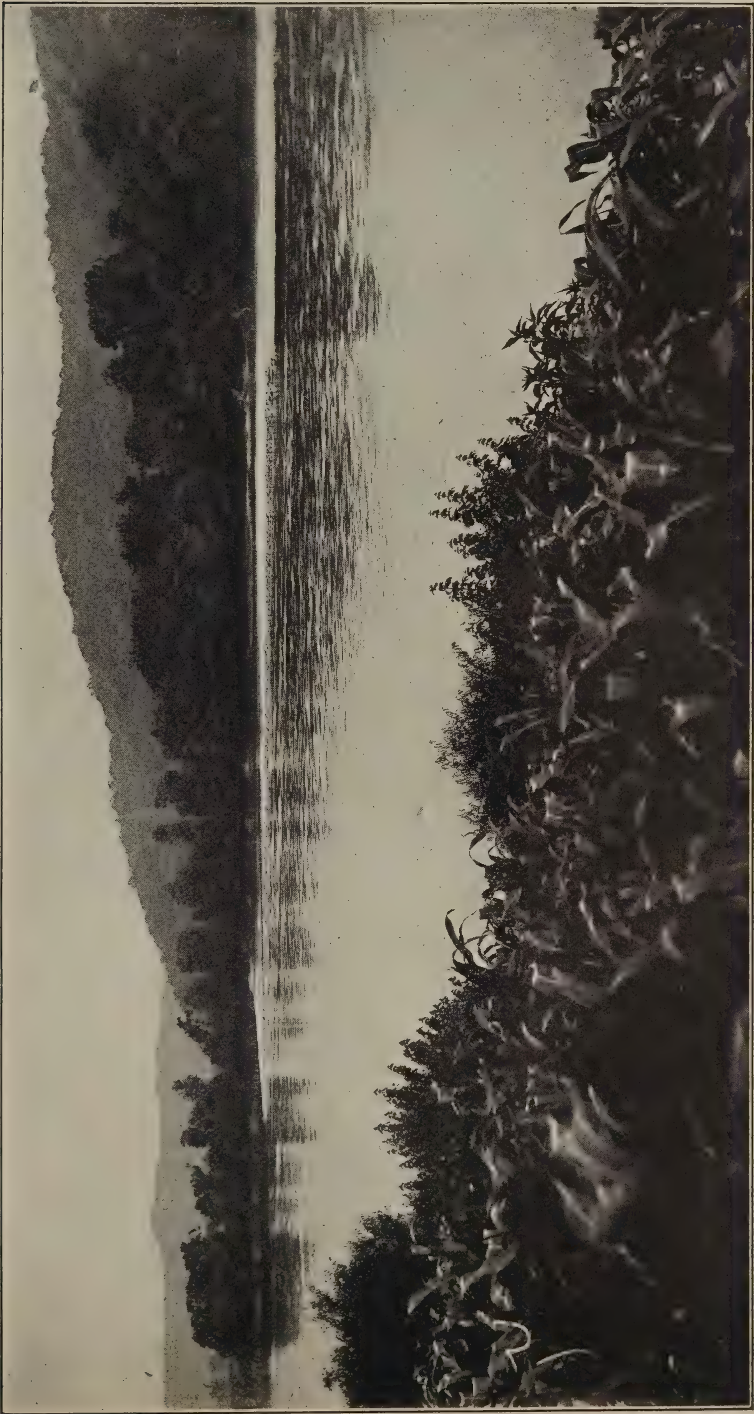


Fig. 12. Watts Bar, view showing lower works. Material dredged, without blasting, during 1913. Channel is along cast dike.

channel width of 150 feet was excavated. At the completion of the work the maximum slope had been reduced from 12 to 8 feet per mile, the maximum current velocity from 5.70 to 5.31 f. s., and the average depth increased to more than 3 feet at extreme low water. Thus Watts Bar was the first improvement completed in full on the Upper Tennessee. For outline of works and other details see Figs. 8 to 12 herewith.

Total and Unit Costs at Watts Bar, 1911-1912.

	Quantities. *Cubic yards.	Linear feet.	Total cost.	Unit cost.
Rock excavation	‡33,746		$31,128.17	$0.922
Gravel excavation	15,754		3,229.57	0.205
Dike construction		5,010	9,787.84	1.954
Total			†$44,145.58	

*Place measurement.

†Includes overhead and depreciation charges.

‡11,500 cubic yards solid rock requiring drilling and blasting, remainder hardpan and shale.

Drilling and Blasting Costs at Watts Bar, 1911-1912.

Number holes.	Linear feet.	Depth of water over rock.	Area blasted. Square feet.	Cost.	Unit cost. Linear foot.
1,243	4,945	4′	38,365	*$3,604.28	$0.729

*Includes overhead and depreciation charges.

Dike Construction Cost at Watts Bar, 1911-1912.

	Quantities. Cubic yards.	Cost.	Unit cost.
Quarrying rock	4,200	$3,142.54	‡$0.748
Loading rock	*8,777	1,790.15	‡0.204
Towing rock	*8,777	2,033.97	‡0.232
Placing rock in dikes	†11,277	2,821.18	‡0.250

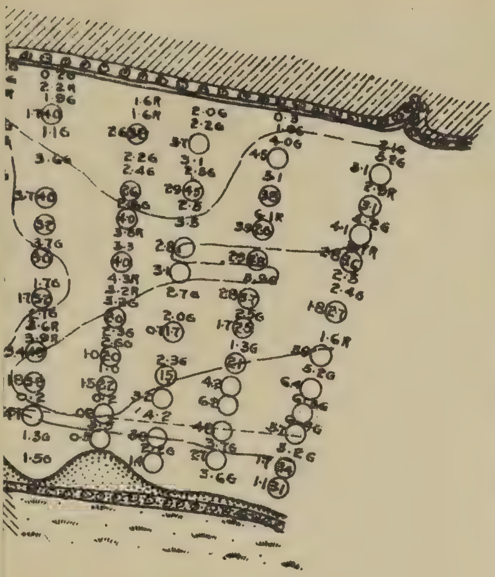
*Includes rock from channel excavation.

†Includes rock shifted from old dike as well as channel and quarried rock.

‡Includes overhead and depreciation charges.

KELLYS SHOALS.

This shoal is located 47 miles above Chattanooga. The records of the earliest Government work here show that a slight quantity of loose rock was excavated from the channel in 1874, and later

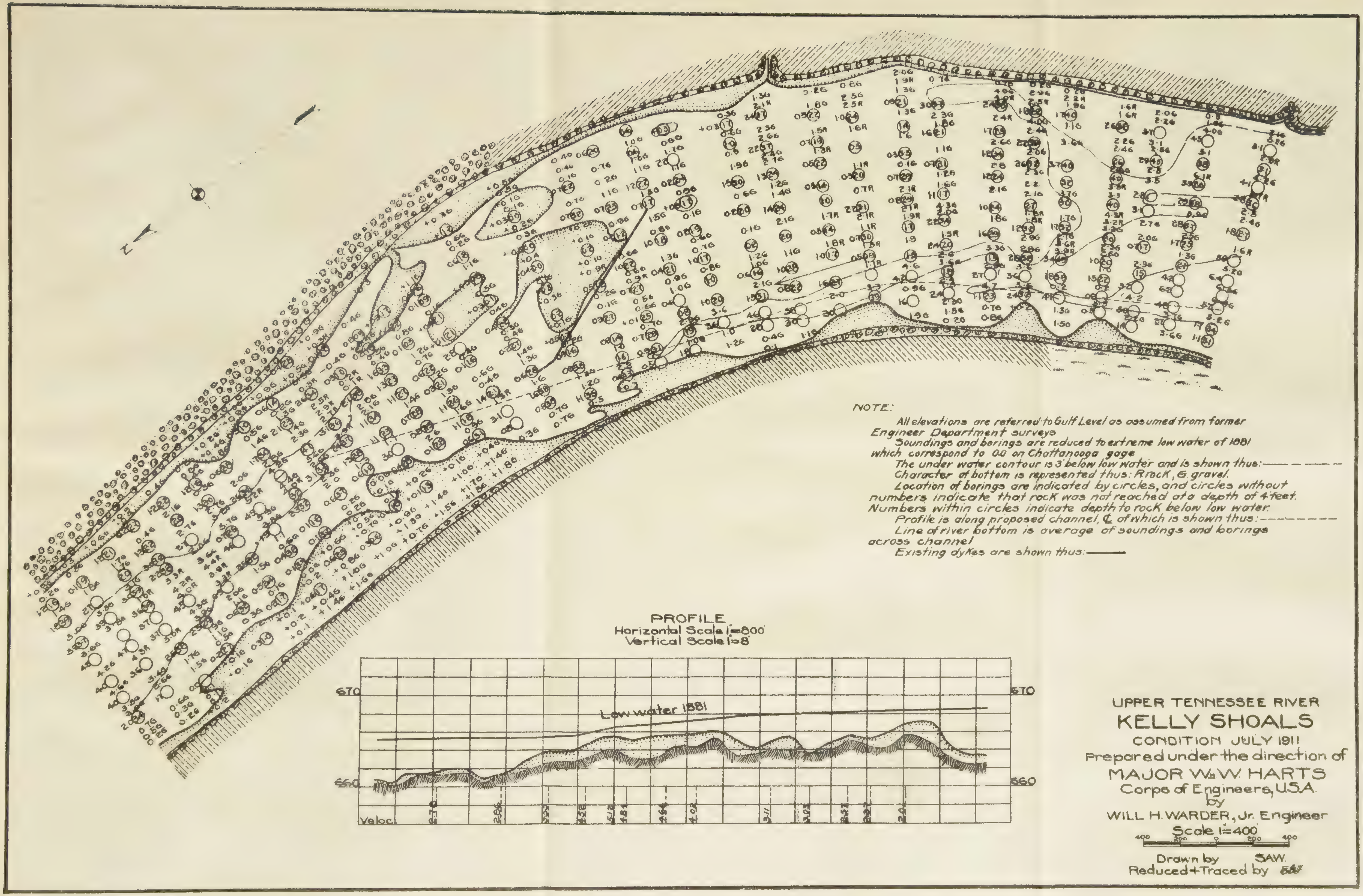


to Gulf Level as assumed from former
ys.
reduced to extreme low water of 1881
attanooga gage
is 3' below low water and is shown thus:— — — — —
resented thus: R. rock, G. gravel.
dicated by circles, and circles without
ck was not reached at a depth of 4 feet.
icate depth to rock below low water.
channel, ℄ of which is shown thus:- - - - - - - -
average of soundings and borings

n thus:———

UPPER TENNESSEE RIVER
KELLY SHOALS
CONDITION JULY 1911
Prepared under the direction of
MAJOR W. W. HARTS
Corps of Engineers, U.S.A.
by
WILL H. WARDER, Jr. Engineer
Scale 1"=400'

Drawn by SAW.
Reduced + Traced by E.W.


PROFILE
Horizontal Scale 1"=800'
Vertical Scale 1"=8'
670
660
Low water 1881
Veloc.
2.78
2.86
3.33
4.58
5.12
4.81
4.64
4.02
3.11
3.05
3.57
2.27
2.01
N

NOTE:

All elevations are referred to Gulf Level as assumed from former Engineer Department surveys

Soundings and borings are reduced to extreme low water of 1881 which correspond to 0.0 on Chattanooga gage

The under water contour is 3' below low water and is shown thus: — — — —

Character of bottom is represented thus: R rock, G gravel.

Location of borings are indicated by circles, and circles without numbers indicate that rock was not reached at a depth of 4 feet. Numbers within circles indicate depth to rock below low water.

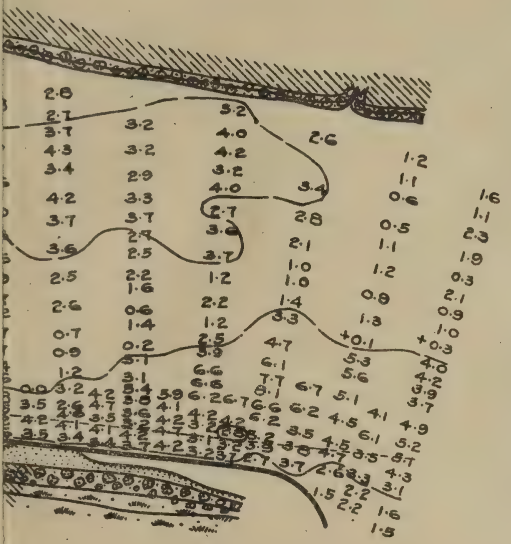
Profile is along proposed channel, ℄ of which is shown thus: - - - - - - - -

Line of river bottom is average of soundings and borings across channel

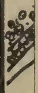
Existing dykes are shown thus: ———

UPPER TENNESSEE RIVER
KELLY SHOALS
CONDITION JULY 1911
Prepared under the direction of
MAJOR Wm. W. HARTS
Corps of Engineers, U.S.A.
by
WILL H. WARDER, Jr. Engineer
Scale 1"=400'
400 200 0 200 400
Drawn by SAW.
Reduced + Traced by GG

Fig. 13. Kelly Shoals, condition 1911 before final improvement.


2.8
2.7
3.7
4.3
3.4
4.2
3.7
3.6
2.5
2.6
0.7
0.9
1.2
3.2
3.2
2.9
3.3
3.7
2.7
2.5
2.2
1.6
0.6
1.4
0.2
3.2
4.0
4.2
3.2
4.0
2.7
3.7
1.2
2.2
1.2
2.5
6.6
2.6
3.4
2.8
2.1
1.0
1.0
1.4
3.3
4.7
6.1
7.7
1.2
1.1
0.6
0.5
1.1
1.2
0.9
1.3
+0.1
5.3
5.6
1.6
1.1
2.3
1.9
0.3
2.1
0.9
1.0
+0.3
4.0
4.2
3.9
3.7
4.9
5.2
4.3
3.1
1.6
1.5

rred to Gulf Level as assumed
partment surveys
ced to extreme low water of
to 0.0 on Chattanooga gage
nnel, ℄ of which is shown thus:---------
re shown thus: ———
ntour is 3' below low water and
– – ———



70

UPPER TENNESSEE RIVER
KELLY SHOALS
CONDITION AUGUST 1913

60

Surveyed under the direction of
MAJOR H BURGESS
and
CAPTAIN R.C. MOORE
Corps of Engineers, U.S.A.
by
Edward G Freiler, Surveyor

Scale 1" = 400'
400 200 0 200 400

Drawn by E.G.F.
Traced by E.G.F.

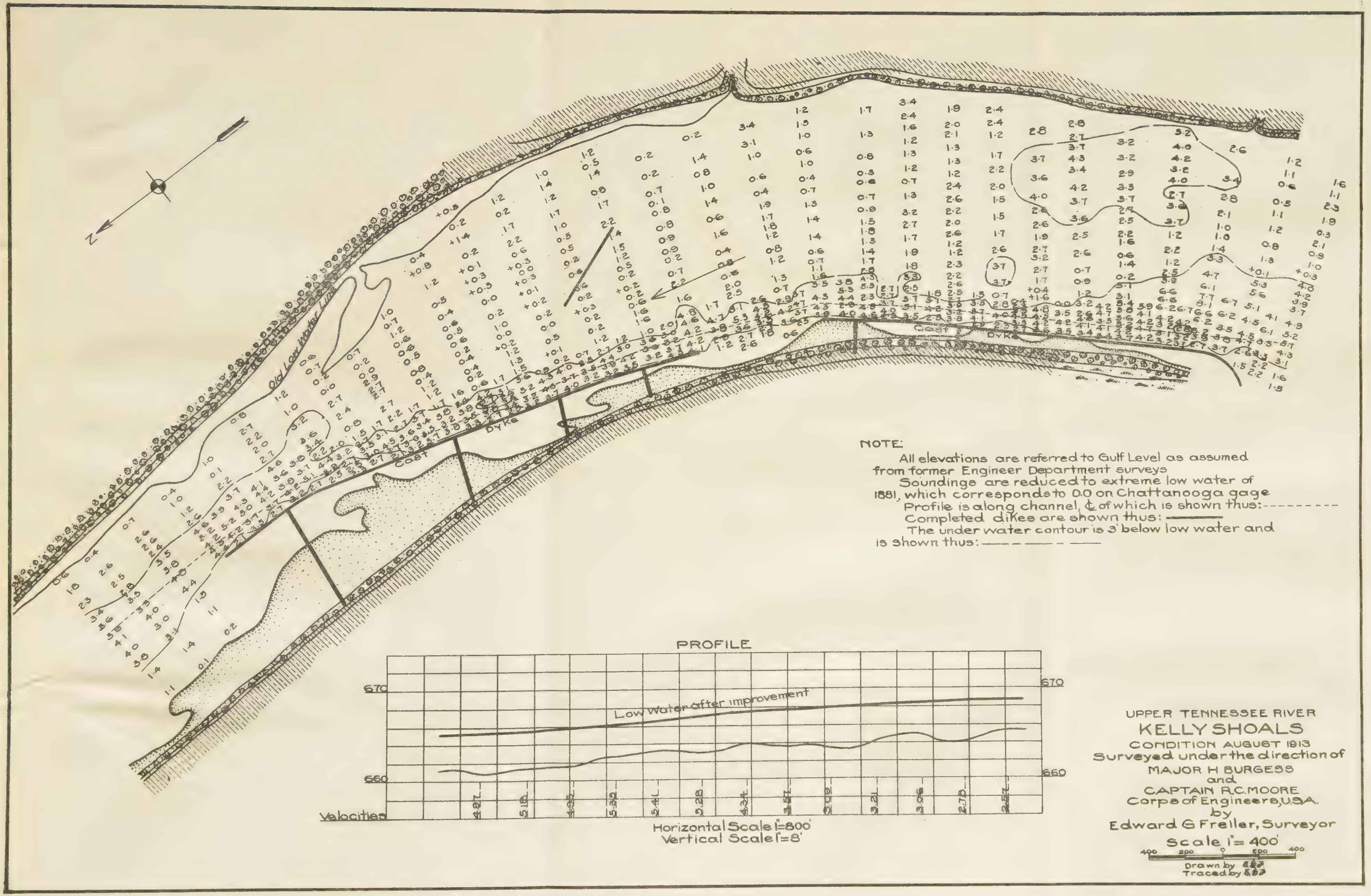

N
Old Low Water Line
Cast
Dyke
Cast
Dyke
Cast
Dyke
NOTE:
All elevations are referred to Gulf Level as assumed from former Engineer Department surveys
Soundings are reduced to extreme low water of 1881, which corresponds to 0.0 on Chattanooga gage
Profile is along channel, ℄ of which is shown thus: - - - - - - - -
Completed dikes are shown thus:
The under water contour is 3' below low water and is shown thus: — — — — —
PROFILE
670
670
Low Water after improvement
660
660
Velocities
4.27
5.18
4.35
5.32
5.41
5.28
4.34
3.57
3.09
3.21
3.06
2.78
2.57
Horizontal Scale 1"=800'
Vertical Scale 1"=8'
UPPER TENNESSEE RIVER
KELLY SHOALS
CONDITION AUGUST 1913
Surveyed under the direction of
MAJOR H BURGESS
and
CAPTAIN R.C.MOORE
Corps of Engineers, U.S.A.
by
Edward G Freiler, Surveyor
Scale 1"= 400'
400 200 0 200 400
Drawn by E.G.F.
Traced by E.G.F.

Fig. 14. Kelly Shoals, condition 1913 after final improvement.

records do not relate any further attempt until 1911, when the final operations were begun. The fact that a heavy wing dike was in existence here at the beginning of final operations seems to indicate that the same was built under state supervision prior to 1874. At the date of the beginning of the final improvement at this shoal, a survey showed that the principal thing to be overcome was the shallow depths, slopes and current velocities being inexcessive. The plan adopted proposed an excavated channel extending from the left bank at the head downstream to mid-stream at the foot of shoal. The first or left cut was to be cast to the left and form a wall marking the location of channel. In addition some of the old wing dike was to be removed in order to increase the cross-sectional area sufficiently at that point to prevent prohibitive velocities in the channel.

The improvement has been completed, except for the removal of a few loose rock, and the following comparison noted: The maximum slope of 12 feet to the mile has been reduced to about 6 feet per mile and the average depth increased from 2 feet to 3 feet at extreme low water. Complaint has been raised against this improvement by the navigation interests, owing to the channel having been dredged and confined across the natural direction of flow. At the epoch of submergence of the cast dike, a draw over the dike is produced, and this condition is no doubt objectionable. However, if this does not cause a filling up of the channel along the dike, the work can be considered satisfactory and of great benefit to navigation. The opinion is ventured that this improvement, because of the above imperfection, will not prove as satisfactory as the Little River Shoals and Watts Bar improvements, both of which conform very closely with the natural flow of water.

Total and Unit Costs at Kellys Shoal, 1911-1912.

	Quantities. *Cubic yards.	Linear feet.	Total cost.	Unit cost.
Rock excavation	22,226		$47,519.19	$2.138
Gravel excavation	29,560		11,380.60	0.385
Dike construction		7,950	20,002.20	2.516
Total			†$78,901.99	

*Place measurement.

† Includes overhead and depreciation charges.

LYONS, WILLIAMS, AND DALLAS SHOALS.

Though it was the prime object of this paper to give actual accomplishments in open-channel work on the Upper Tennessee River, relating both good and bad features of the works under consideration, it has occurred to the writer that it would be well to give a brief account of the plans for improving Lyons, Williams, and Dallas shoals, which have only recently been completed. It is proposed that the work at these localities will be the next undertaken. From the preceding observations the reader will be enabled to decide for himself whether or not the Government is taking advantage of experience gained in the past.

Lyons Shoals.

The head of Lyons Shoals is about 12 miles below the source of the river and 176 miles above Chattanooga. This obstruction extends over a distance of about 1 mile and consists of gravel bars and rock reefs covered with an average depth of about 1½ feet. The maximum slope is 13½ feet per mile, and since the allowable maximum slope of an improved section has been selected as not to exceed 8 feet per mile, this maximum must be reduced by the works.

The plan adopted for the improvement of this shoal provides for a bank channel down the right chute, and the method to be used in effecting same will be contraction as the main factor with excavation supplemental. In deciding upon the right chute for the location of channel, cost of construction was the first consideration and cost of maintenance the second. A comparison between the right and the left chute was made in detail. It is proposed to extend the existing wing dike downstream a distance of 1,200 feet, the curve of dike conforming closely to the curve of right bank, with a maximum contraction at the lower end of 300 feet; to build a longitudinal dike beginning at a point on the right bank of Lyons Island, about 75 feet above lower end, extending downstream 1,700 feet, with a contraction of 300 feet at its lower end; and to build a short spur dike from island at a point about midway between upper and lower longitudinal dikes. As usual, the longitudinal dikes are to be connected with the island bank by checks making angles of about 15 degrees upstream with thread of stream. In the plan outlined above, the old wing dike which was built some thirty-five years ago is conserved. The estimated cost of this improvement is $25,415.16, as follows: 27,184

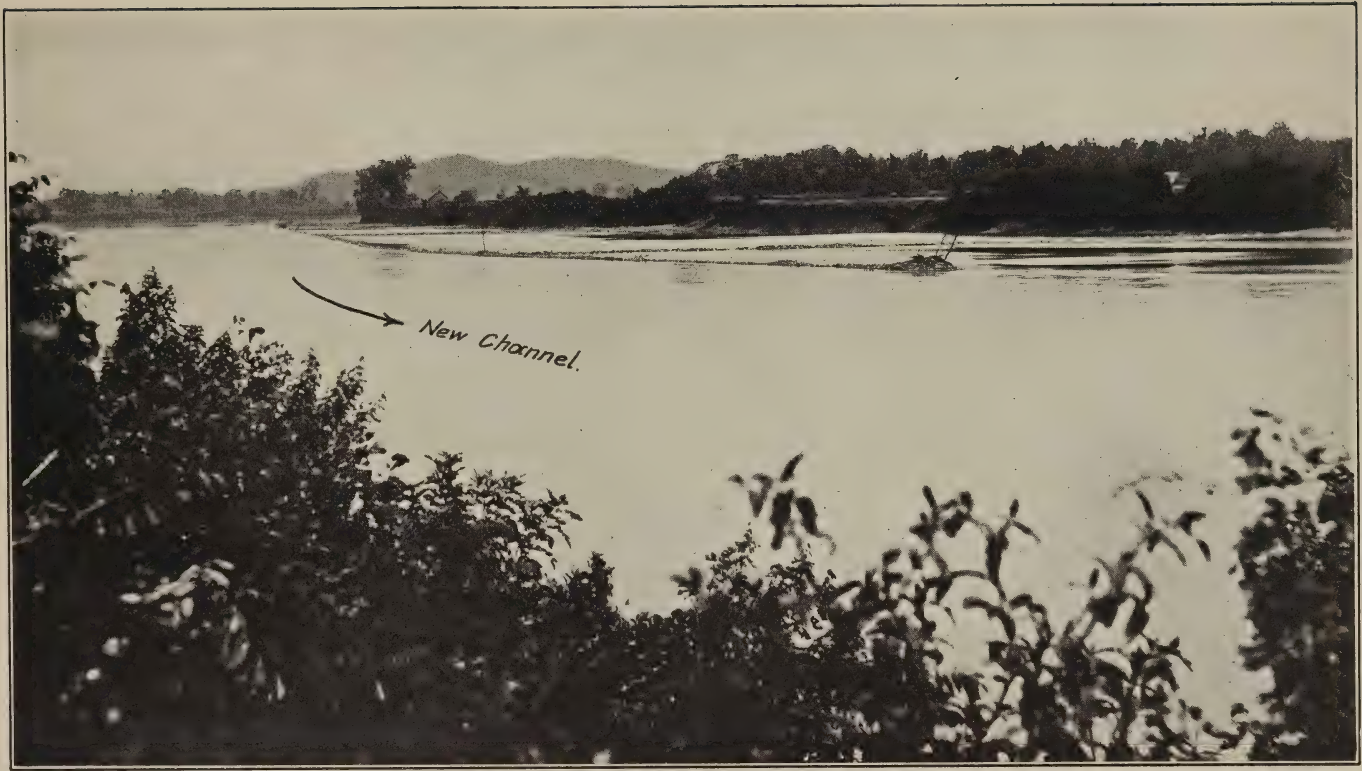


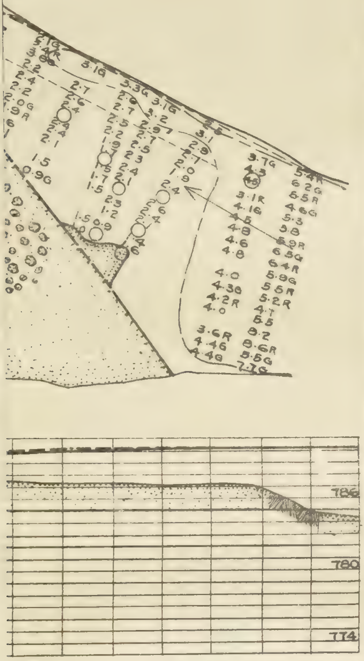
Fig. 15. Kelly Shoals, view showing works looking upstream from right bank. Note willow sprouts set out by the United States to add to stability of dike.

cubic yards, place measurement, gravel excavation at 20 cents, 10,184 cubic yards quarried rock in dikes at $1.50, 20 per cent or $4,235.86 for contingencies. The above figures are based on an allowance of 1 foot for overcut. See Fig. 16 herewith.

Williams Shoals.

These shoals are located about 1 mile below Lyons Shoals, and conditions here are very similar to those at the shoal above, except that slopes and resulting velocities are not so great. The problem then is one of securing project depths without increasing velocities too much.

The adopted plan of improvement contemplates a bank channel down the left chute, and the method to be used is again contraction supplemented by excavation. As at Lyons Shoals, the selection of this method was influenced by the possibility of thus reducing appreciably the quantity of rock and gravel excavation. The plan as laid calls for the construction of a longitudinal dike, with its head at a point on right bank near sharp curve in bank at head of shoals, to extend downstream to a point about 400 feet below towhead and 350 feet below a point opposite foot of Johnsons Island, touching Williams Island. The maximum contraction, which is at the foot of the dike, is 300 feet. Another longitudinal dike is to extend downstream from near the foot of Williams Island a distance of 1,750 feet, causing a maximum contraction of 300 feet at lower end. A check or cross dike is to connect this dike to right bank below foot of island. Similar to the plan at Lyons the subordinate dredging is to follow the bank, the first cut being cast against the bank. In 1882, the United States did some little channel work in the right chute and built a short rock dike connecting Williams Island and the little towhead above, but other than this very little has ever been done, therefore the changing of the channel from right to left chute is not so radical. The new channel, being straight, will be easy to navigate and will no doubt maintain itself at least as well as would one down the right chute. The cost of this improvement was estimated as follows: 22,476 cubic yards, place measurement, gravel excavation at 20 cents; 4,694 cubic yards, place measurement, rock excavation at $2.00; 4,000 cubic yards, place measurement, rock from channel in dikes at 75 cents; 6,065 cubic yards quarried rock in dikes at $1.50; contingencies, $5,196.14 (20 per cent). An allowance of


3.1G
3.3G
3.1G
2.7
2.6
2.4
2.2
2.0G
2.5
2.2
1.9
1.7
1.5
2.3
1.2
3.1
2.9
2.7
2.0
1.9
2.4
1.5
0.9G
3.7G
4.3
3.1R
4.1G
4.8
4.6
4.0
4.3G
4.2R
3.6R
4.4G
5.4R
6.2G
6.5R
4.6G
5.3
5.8
5.9R
6.5G
6.4R
5.9G
5.5R
5.2R
5.5
8.2
8.6R
5.5G
7.7G
786
780
774

UPPER TENNESSEE RIVER

LYONS SHOALS

CONDITION NOVEMBER 1913
Prepared under the direction of
MAJOR H. BURGESS
and
CAPTAIN R.C. MOORE
Corps of Engineers, U.S.A.
Scale 1"=400'
400 200 0 200 400
Surveyed by G.W. & C.F.B.
Reduced & Traced by E.B.J.

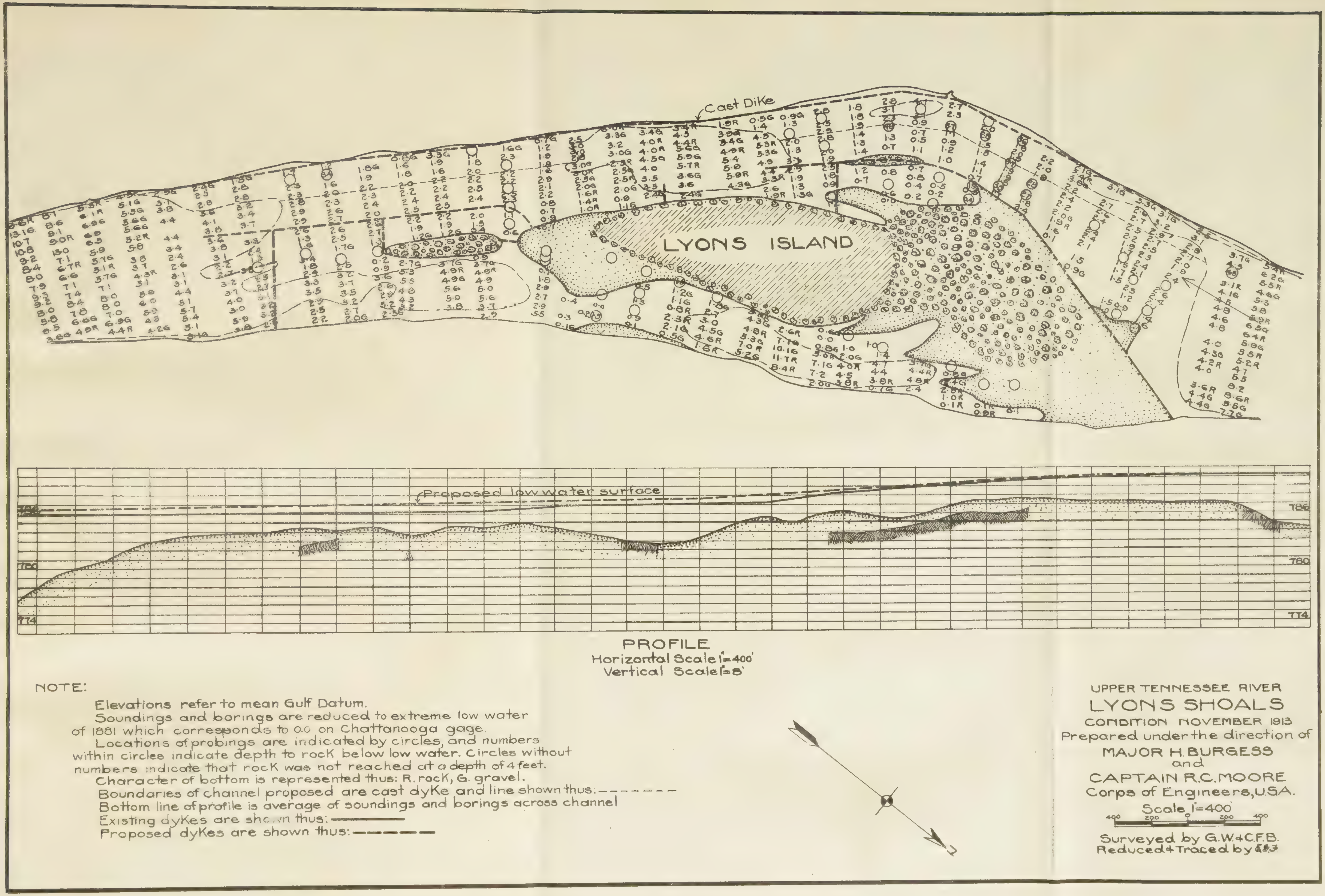
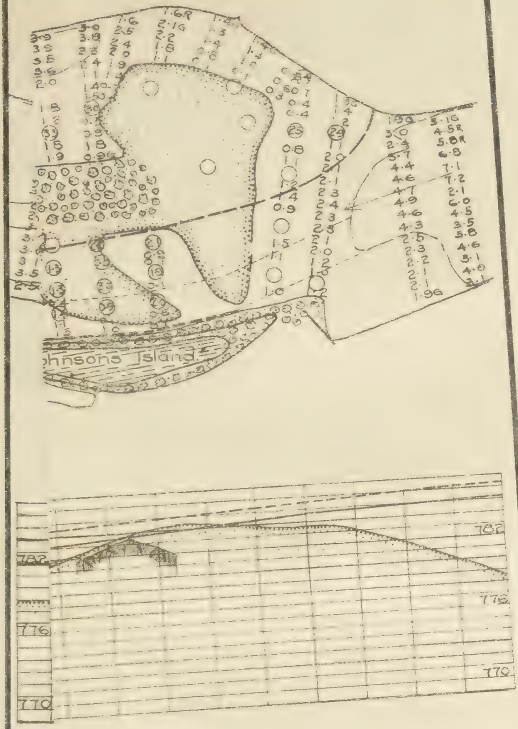

Cast Dike
LYONS ISLAND
Proposed low water surface
786
780
774
PROFILE
Horizontal Scale 1"=400'
Vertical Scale 1"=8'
NOTE:
Elevations refer to mean Gulf Datum.
Soundings and borings are reduced to extreme low water of 1881 which corresponds to 0.0 on Chattanooga gage.
Locations of probings are indicated by circles, and numbers within circles indicate depth to rock below low water. Circles without numbers indicate that rock was not reached at a depth of 4 feet.
Character of bottom is represented thus: R. rock, G. gravel.
Boundaries of channel proposed are cast dyke and line shown thus: - - - - - - -
Bottom line of profile is average of soundings and borings across channel
Existing dykes are shown thus: ————
Proposed dykes are shown thus: — — — —
UPPER TENNESSEE RIVER
LYONS SHOALS
CONDITION NOVEMBER 1913
Prepared under the direction of
MAJOR H. BURGESS
and
CAPTAIN R.C. MOORE
Corps of Engineers, U.S.A.
Scale 1"=400'
400 200 0 200 400
Surveyed by G.W.&C.F.B.
Reduced & Traced by E.B.J.

Fig. 16. Lyons Shoals, condition 1913 before improvement. Shows plan to be followed in effecting improvement.

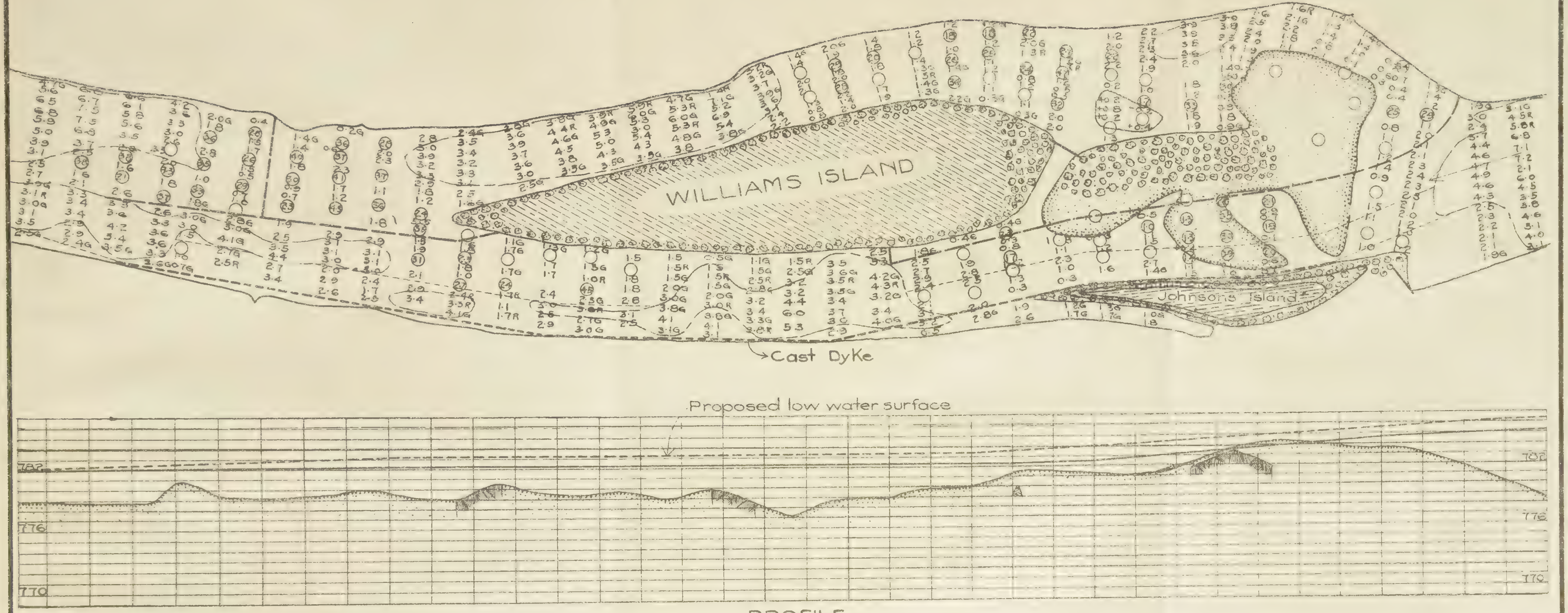

Johnsons Island
782
776
770
782
776
770

UPPER TENNESSEE RIVER

WILLIAMS SHOALS

CONDITION NOVEMBER 1913
Prepared under the direction of
MAJOR H. BURGESS
and
CAPTAIN R.C. MOORE
Corps of Engineers, U.S.A.
Scale 1"=400'
400 200 0 200 400
Surveyed by G.W. & C.F.B.
Reduced & Traced by

.ent.



PROFILE
Horizontal Scale 1"=400'
Vertical Scale 1"=8'

NOTE:

Elevations refer to mean Gulf Datum

Soundings and borings are reduced to extreme low water of 1881 which corresponds to 0.0 on Chattanooga gage

Locations of probings are indicated by circles and numbers within circles indicate depth to rock below low water, Circles without numbers indicate that rock was not reached at a depth of 4 feet.

Character of bottom is represented thus: R rock, G gravel.

Boundaries of channel proposed are cast dyKe and line shown thus: ---------

Bottom line of profile is average of soundings and borings across channel

Existing dyKes are shown thus: ————

Proposed dyKes are shown thus: —— —— ——

UPPER TENNESSEE RIVER
WILLIAMS SHOALS
CONDITION NOVEMBER 1913
Prepared under the direction of
MAJOR H. BURGESS
and
CAPTAIN R.C. MOORE
Corps of Engineers, U.S.A.
Scale 1"=400'
400 200 0 200 400
Surveyed by G.W. & C.F.B.
Reduced & Traced by E.S.C.

Fig. 17. Williams Shoals, condition 1913 before improvement. Shows plan to be followed in effecting improvement.

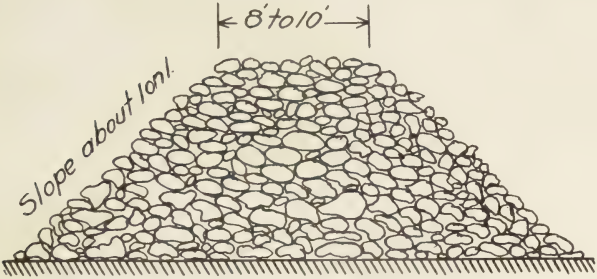

8' to 10'
Slope about 1 on 1.

Fig. 20.

Approximate cross-section of check, spur, and wing dikes built of one-man size quarried and channel rock.

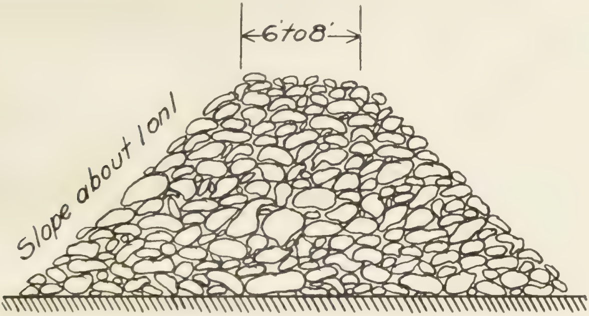

6' to 8'
Slope about 1 on 1

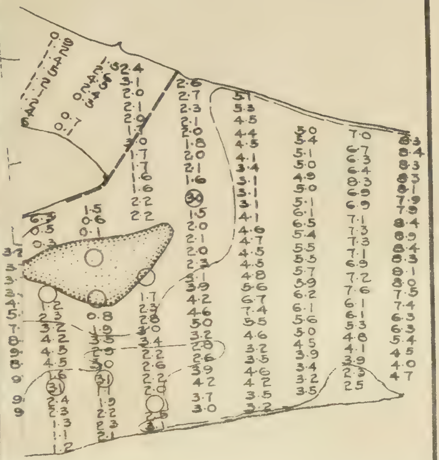
Fig. 21

Approximate cross-section of longitudinal dikes built of one-man size quarried and channel rock.

1 foot for overcut is made in calculating quantities for excavation. See Fig. 17 herewith.

Dallas Shoals.

These shoals occur 14 miles above Chattanooga. Compared with the various shoals previously considered, they are of minor importance, which probably accounts for the lack of previous attempts at improvement here. The average depths are about 2½ feet, and the slopes and current velocities are almost negligible. The obstruction consists of gravel bars at the head and foot of Dallas Island, left chute. In this case the right chute was not considered, owing to its being developed at the time of survey that the depths in that chute were too small for consideration. In view of the nonexistence of extreme slopes and current velocities and of the material of bed being gravel above the proposed depth, the method of improvement by excavation with contraction subordinate is at once suggested as being the more economical as well as productive of results. A comparison of the two methods divulged that the excavation method was the one that should be employed. In other words, the computations showed that in this case, as in most cases, it would be cheaper to excavate gravel than to quarry stone and build dikes, and, further, that there was no apparent necessity for contraction. The plan adopted proposes the closing of right chute at head of Dallas Island by quarried stone dike, with the result that the shallow bar opposite the head of island will be drowned out. At the lower bar, dredging along the left bank is proposed, the first cut to be cast to the left and this dredged dike to be tied to the bank by checks of dredged material. Provision for two spur dikes to extend from the right bank below foot of island, of sufficient length to compensate for the increased channel cross-sectional area due to dredging, is made. These spurs are to be constructed of dredged material if found stable, otherwise of quarried stone. The increased water surface elevation throughout the length of shoal will be due to the closure of right chute. The estimated cost of this improvement is as follows: 13,220 cubic yards, place measurement, gravel excavation at 20 cents; 1,425 cubic yards, loose measurement, quarried rock in dikes at $1.50; 2,100 cubic yards excavated material in dikes at 75 cents; and $1,271.30 for contingencies (20 per cent). The usual allowance of 1 foot for overcut for excavation was made. See Figs. 18 and 19 herewith.



UPPER TENNESSEE RIVER

DALLAS SHOALS

CONDITION NOVEMBER 1913

Prepared under the direction of

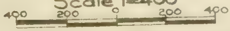
MAJOR H BURGESS

and

CAPTAIN R.C. MOORE

Corps of Engineers, U.S.A.

Scale 1"=400'



Surveyed by G.W. + C.F.B.

Reduced + Traced by

For notes see sheet 2.

Sheet 1.

LIBRARY OF THE UNIVERSITY OF ILLINOIS

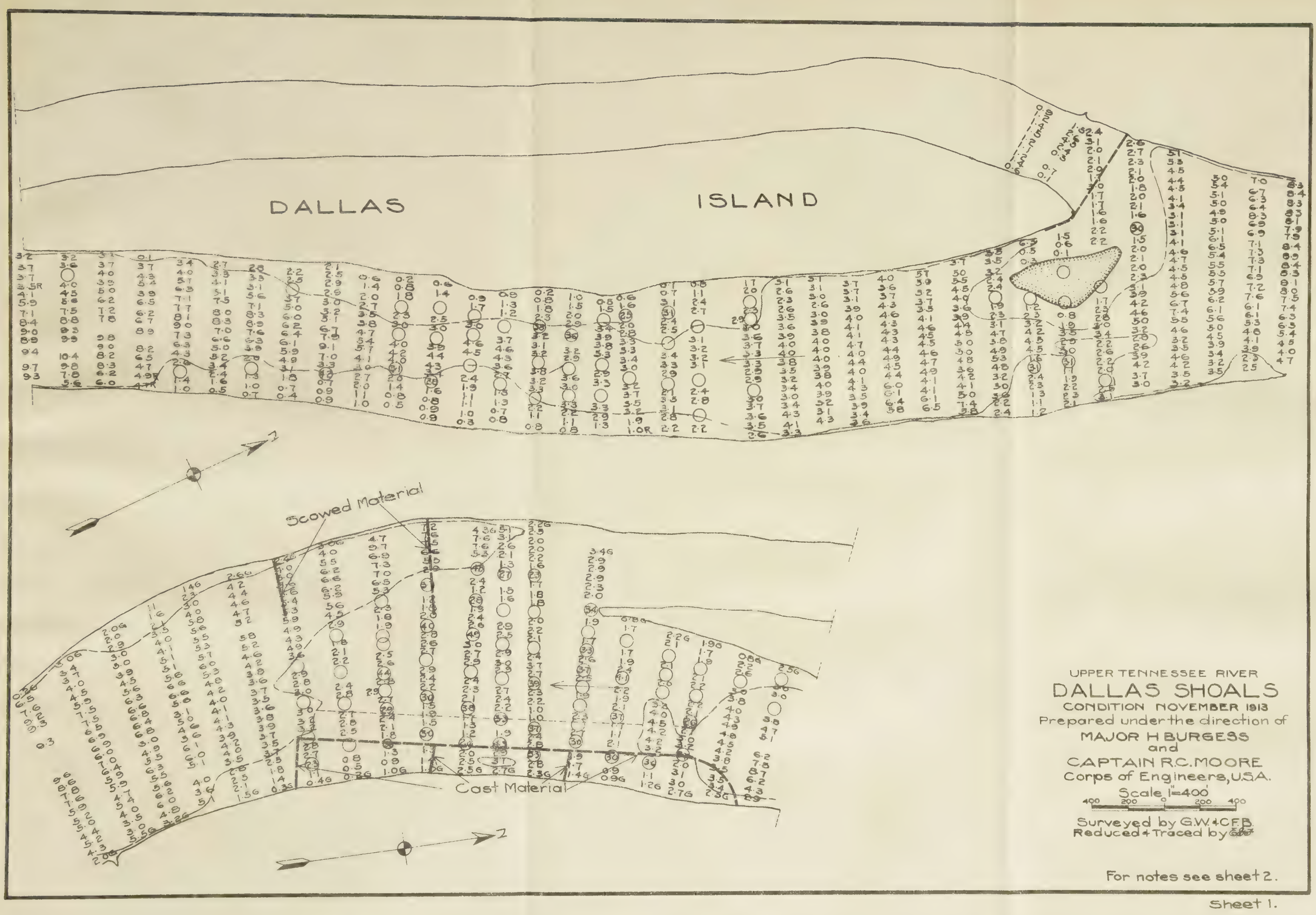
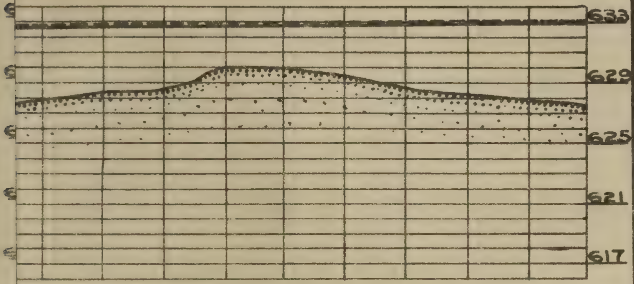
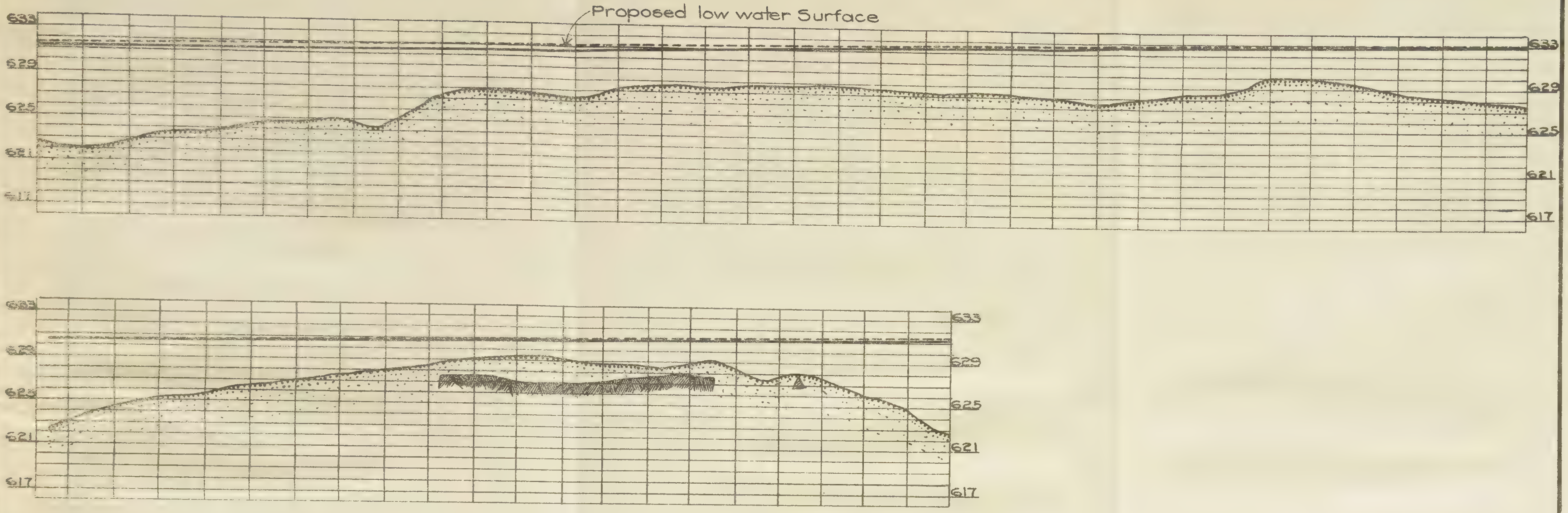

DALLAS ISLAND
Scowed Material
Cast Material
N
UPPER TENNESSEE RIVER
DALLAS SHOALS
CONDITION NOVEMBER 1913
Prepared under the direction of
MAJOR H BURGESS
and
CAPTAIN R.C. MOORE
Corps of Engineers, U.S.A.
Scale 1"=400'
400 200 0 200 400
Surveyed by G.W. & C.F.B.
Reduced & Traced by G.W.
For notes see sheet 2.
Sheet 1.

Fig. 18. Dallas Shoals, condition 1913 before improvement. Shows plan to be followed in effecting improvement.



UPPER TENNESSEE RIVER
DALLAS SHOALS
PROFILE ALONG PROPOSED CHANNEL
CONDITION NOVEMBER 1913
Prepared under the direction of
MAJOR H. BURGESS
and
CAPTAIN J.J. BAIN
Corps of Engineers, USA.
Horizontal Scale 1"=400'
Vertical Scale 1"=8'
Surveyed by G.W.&C.F.B.
Drawn+Traced by E.G.J.
Sheet 2.

fter improvement.



NOTE:

Elevations refer to mean Gulf Level

Soundings and borings are referred to extreme low water of 1881 which corresponds to 0.0 on Chattanooga gage

Location of borings are indicated by circles and numbers within circles indicate depth to rock below low water, Circles without numbers show that rock was not reached at a depth of 4'

Character of bottom is represented thus: R. rock, G. gravel.

Boundaries of proposed channel are cast dyke and line shown thus:- - - - - -

Bottom line of profile is average of soundings and borings across channel.

Existing dykes are shown thus:———

Proposed dykes are shown thus:— — — —

Under water contour is 3' below low water and is shown thus:— — — — — — —

UPPER TENNESSEE RIVER
DALLAS SHOALS
PROFILE ALONG PROPOSED CHANNEL
CONDITION NOVEMBER 1913
Prepared under the direction of
MAJOR H. BURGESS
and
CAPTAIN J.J. BAIN
Corps of Engineers, U.S.A.
Horizontal Scale 1"=400'
Vertical Scale 1"=8'
Surveyed by G.W.&C.F.B.
Drawn+Traced by E.G.J.
Sheet 2.

Fig. 19. Dallas Shoals. Profile showing condition 1913 before improvement. Shows proposed water surface after improvement.

CONCLUSION.

Many engineers believe that the day of open-channel improvement of rivers has passed, or is fast passing, and that it must of necessity give way to the more modern method of improvement by canalization. While there is little doubt of the superiority of the latter, it would seem that the former has its sphere, in view of its cheapness, immediate benefits, adaptability to streams whose banks are low, and its necessary employment on streams whose commerce does not justify extensive works, which will make its use quite as frequent in the future as in the past. More is being learned about this method of improvement each year, but until the lesson is learned that little credence can be placed in calculations or plans based on assumptions throughout, when it is possible to ascertain actual values by taking a little time for observations, a high degree of efficiency can not be attained. In other words, at the present time our calculations for open-channels are not based on accurate information such as would be essential in the design of other engineering works.

Concluding, I wish to acknowledge receipt of valuable assistance, in the preparation of drawings for this article, from Surveyor Edward G. Freiler.

Use and Development of the Ponton Equipage in the United States Army, with Special Reference to the Civil War

BY

Maj. M. J. McDONOUGH *and* Maj. P. S. BOND
Corps of Engineers , U. S. Army

No record is found showing that the United States had, prior to the Mexican War, any prepared means for the passage of its armies over streams. During that war the necessity for such equipage having become apparent, two complete trains were constructed and put into the field. The trains did not arrive in time to be of service in Taylor's northern expedition. They accompanied Scott's advance from Vera Cruz. Scott had much less need for the equipage in his advance than had Taylor.

The supports for this equipage were of the floating type, and were made of rubber. Each float or ponton consisted of three cylinders of canvas fastened together, waterproofed inside and out with vulcanized rubber and divided into inflatable compartments. Each ponton was encompassed by a wooden frame, on which rested a floor system essentially similar to the present service floor system.

This equipage is described in "Haupt's Military Bridges," and also in complete detail in "Professional Papers No. 4, Corps of Engineers."

In its early peace trials the equipage met the tests. In the Mexican War, for which it was especially designed, it received no thorough test. At the close of the war the material was shipped to West Point to be used in the instruction of cadets and Engineer soldiers. Some remnants of this material were still there at the opening of the Twentieth Century. Within a few years after its arrival at West Point, much of the material deteriorated and had to be submitted to a Board of Survey. The Board reported the cause of deterioration to be the action of sulphuric acid (in the rubber) on the canvas walls of the cylinders. General Totten, then Chief of Engineers, directed the Superintendent of the Academy, Col. Robert E. Lee, to seek means of preserving the equipage from further deterioration and to make tests to determine upon a suitable equipage.

The endeavors to arrest the deterioration of the rubber cylinders proved fruitless, but systematic work was undertaken looking to the adoption of some more suitable equipage.* The officers chiefly engaged upon this work were B. S. Alexander, G. W. Cullum, and J. C. Duane, all of the Corps of Engineers. In the course of the work Captain Cullum went to Europe to examine the European systems of bridging. His studies resulted in a work, ''Systems of Military Bridges,'' which appears as ''Professional Papers No. 4, Corps of Engineers.'' It includes a description of the equipage adopted for the American Army. This publication was thereafter used as a service manual, and was the basis upon which requisitions for bridge equipage were made. The book shows thorough and extensive study and experiment. It was fortunate that much continuity in the personnel engaged on this work was maintained, so that their work is the logical result of comprehensive study rather than a hash of the opinions of a constantly changing board, so customary in the development of the American Army.

THE WEST POINT EXPERIMENTS.

The first fruit of the experimental work at West Point was the definite rejection of the rubber cylinder system, for three reasons:

1st. The deterioration due to sulphuric acid.

2nd. The great lack of stiffness of the bridge, rendering it unsafe for the passage of animals.

3rd. Peculiar vulnerability to destruction by projectiles, either above or below the water line.

In searching for a successor to the rejected equipage, three (3) conditions were laid down which must be fulfilled by an equipage to insure acceptance. These conditions are of great importance,

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*Barnard.—Reb. Records, Serial Number 12, p. 127.
Gilbert Thompson.—Eng. Battalion in Civil War, p. 5.
Ponton Manual, pp. 11-13.
Systems of Military Bridges.—Cullum.

and deserve to be held in mind throughout the reading of this paper; they were:

1st. Mobility sufficient to insure the presence of the train with the marching column.

2nd. Ferrying capacity.

3rd. Bridging capacity proper—the equipage must be capable of passing with safety the heavy trains of an army over the largest and swiftest streams likely to be encountered.

The experiments included trials of practically all the European systems. Particular attention was paid to the French Whole Ponton, the Austrian Sectional Ponton, the Russian Canvas Ponton, and to the Austrian Birago Trestle.

The pontons were built of wood and also of corrugated iron of practically the same shapes. Several of the other European nations at that time were in the act of changing* their equipages because they were found to be unsatisfactory. The Board concurred in the dissatisfaction. The British at this time were using an air-tight tin ponton. It was believed to be open to much the same objections as the rubber cylinders. The construction of the experimental bridge material was done by Engineer troops. The material was subjected to severe tests of heavy loads, storms, tides, and ice.

General Barnard, in speaking of the work at West Point at this time, said:†

> The ponton equipage which accompanied the Army was devised, as already mentioned, by Lieutenant Colonel Alexander, assisted by Capt. J. C. Duane. The former had acquired an enviable reputation as the builder of Minots Ledge Lighthouse, possessed great practical ingenuity, and had the means of knowing the best results arrived at in other services in this branch of military art. Captain Duane possessed a more extensive and thorough practical and experimental knowledge of military bridges than any other man in the country. These officers had before them the best modern inventions of Europe and America. The india-rubber ponton they knew thoroughly; corrugated iron bodies, and countless other inventions of American genius were before them and the former experimented upon.

Captain Cullum writes of the investigations of the officers as follows:

French System.—The normal bridge support in this system is the single bateau, which possesses stability, simplicity, requires no adjustment of parts, will sustain all necessary military burthens, can easily be navigated, is suitable for the transportation of troops and materials. . . . No system has been so thoroughly tested by long and varied experience of actual war; the French equipage, therefore, may be pronounced the most reliable of all existing bridge equipages.

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*Ponton Manual.

Recherches sur les Equipages de Ponts Militaires en Europe. Birago, 1845.

† Reb. Records, S. N. 12, p. 127.

Sectional Systems—such as the Austrian.—After the experiments on the Danube which resulted in the adoption of the Birago Bridge Equipage, new trials were made by the French on the Rhine at Strasbourg, which resulted unfavorably, inducing them to adopt no part of the system, except substituting Birago's trestle, somewhat modified.

The advantages of pontons being divisible are more apparent than real. The combination of pieces is complicated; necessitates a perfect identity of the parts and fixtures of the piece to be united, not easily obtainable in practise; and when assembled produces, at best, but a rickety bridge support and too fragile for military purposes. . . . They multiply ponton wagons and considerably increase their loads by the weight of assembling irons. . . . For transporting troops they are disadvantageous, as the two pieces singly are indifferent boats and the body piece can not be navigated at all, and to assemble them together consumes precious time, while the men carried in them are cramped and made uncomfortable by partitions and projecting fixtures. And, finally, the claim for forming bridges with double and triple roadways is far better accomplished by constructing two of these separate bridges. . . . The carriages have a multiplicity of fixtures, and the mode of loading them is difficult, complicated and almost impracticable in the dark.

The Ponton Manual says:*

After experimenting for two years with the above-mentioned material, the following conclusions were reached: The French ponton is superior to the Austrian in simplicity and stiffness; as a ferry boat it will transport more troops and is more easily managed; in the bridge its superiority is marked. With the French equipage, the corresponding balks of the adjacent bays lap each other about 6 feet, and are firmly lashed together and to both gunwales of the ponton, which greatly increases the strength and stiffness of the roadway; while with the Austrian, the balks must meet on a sill directly over the axis of the boat. The bays thus hinging on this sill, full play is allowed to the horizontal and vertical oscillations to which floating bridges are subject.

---

*Page 11. Colonel Duane was the senior member of the Board that wrote the Ponton Manual in 1869. The Manual embodies the results of the experiences of the Civil War in bridge equipage. The influence of Colonel Duane on the Board can be inferred by the fact that the first part of the manual is practically a literal copy of "Printed Papers No. 1 of the Essayons Club;" written by him two years previously.

As to land transportation, the French requires fewer carriages to transport the same length of bridge than the Austrian, since for each section of the latter ponton a separate vehicle is necessary. The length of the two carriages does not differ materially, this being determined by the length of the balks.

These considerations led to the adoption of the French ponton.

The material of which the ponton should be built was decided after considerable experiment to be wood—white pine. The iron boats proved to be quite as heavy as the wooden for equal strength and buoyancy. They would not, however, stand the shocks of land transportation in the peace tests. The rivets would shear, thereby permitting seams to open, and the boats easily acquired permanent distortion. They were difficult to repair and impossible to fabricate, in the field.

It was deemed impracticable with a single equipment to satisfy at once the first and third of the conditions hereinbefore laid down. The French ponton amply fulfilled the second and third conditions, but not entirely the first. To satisfy the first condition it was therefore determined to adopt also the Russian collapsible canvas ponton, which had given satisfaction over a great extent of time. The boat was borrowed almost without change.

The carriage adopted for transporting the loads was a four-wheeled vehicle, with the forward truck capable of turning completely under the body. The equipage was then completed by the adoption of a modified Birago trestle, which was to be used in conjunction with both types of pontons.*

Five trains, each composed of thirty-four wooden pontons and eight trestles, were built in the winter of 1861-1862. At the same time a number of canvas trains were built. A very large part of this equipment was carried to the Peninsula for McClellan's advance on Richmond.

We shall follow the equipage through the course of the Civil War, examining closely its performance, its further development in the school of-war, and its applicability to campaign from the point of view not simply of its designers, but of the leaders of armies. We shall particularly endeavor to see whether it ful-

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*Ponton Manual, p. 13.
Barnard, Reb. Rec. S. N. 12, p. 108.
Duane's Manual, p. 17.

filled the three fundamental requisites laid down at the time of its adoption, viz, mobility, ferrying capacity, bridging capacity.

OPERATIONS IN VIRGINIA.

The first use of the new equipage during the war was the building of a bridge across the Potomac at Sandy Hook, east of Harpers Ferry. The Battalion of Engineers was moved by rail from Washington Arsenal (Washington Barracks) and the equipage also arrived by rail. The bridge was thrown on February 26, 1862.* It consisted of forty-one wooden pontons, the total length being about 840 feet. This was the first such bridge constructed in the United States and much interest was attached to it. The wind was blowing hard at the time and the Potomac was running very full. About eight hours were consumed in the task, which was creditable under the circumstances. The bridge was thrown to facilitate the operations in the Shenandoah Valley. Banks' Corps, with all its artillery and trains, passed at once safely over the bridge. Thus the opening trials of the equipage augured well for its future usefulness during the war.

March 3d a flying bridge was constructed across the Shenandoah River east of Harpers Ferry. The current was very swift and this facilitated the operation of the bridge. March 11th the Engineer Battalion returned by rail to Washington Barracks, leaving at Harpers Ferry a small detail to operate the bridge.

PENINSULA CAMPAIGN.

The next operation involving the use of the pontons in the Eastern theater was the Peninsula Campaign. The Army of the Potomac embarked March 26th at Washington and arrived at Fort Monroe the 28th.† With it were carried five trains of reserve pontons, each train consisting of about thirty-four boats, with eight Birago trestles. Each train was calculated to be able to span about 750 feet. Only four of the wooden trains and one train of canvas equipage were provided with wagons. These were, however, entirely lacking in horse or mule transportation.

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*McClellan, Reb. Rec. Serial No. 5, pp. 48, 727.

Banks, Reb. Rec. Serial No. 5, p. 725.

Gilbert Thompson, "Engineer Battalion in the Civil War." Thompson was an enlisted man in the Battalion of Engineers during the Civil War. He kept a diary, which has since been edited and published as an Occasional Paper No. 44. The diary is valuable as a guide to the operations of the Battalion.

†Barnard, Report, R. R. S. N. 12, p. 108.

Ponton Manual, p. 13.

This equipage was used to a considerable extent in bridging Wormleys Creek at the siege of Yorktown and in the operations of Franklin's Division at Cheeseman's Landing (Ship Point). The organization into trains was largely abandoned in the advance up the Peninsula. One train* was hauled by the Battalion of Regular Engineers in the advance beyond Yorktown. Franklin's Division took by water about seventy pontons in its movement on Eltham Landing (White House), May 6th. The remainder went into depot at Fort Monroe.

The pontons were used for the disembarkation of Franklin's Division and for making landing wharves at Eltham and White House. They were also utilized in the bridging of the Chickahominy, chiefly at New Bridge, as part of the system of bridges used to connect the two wings of the Federal Army. Both wooden and canvas boats were used in this manner on the Chickahominy. The bridge equipage did not play a great part in the vital matter of communication across the troublesome Chickahominy, for the reason that the problem here was solely one of approaches. At its worst the river proper was but a small stream, but its banks were so low and spongy and withal so extensively subject to overflow that the corduroying of the approaches became an immense task. The total length of crossings from end to end of the corduroying ran in one case 1,200 feet (bridge below New Bridge); the bridge 2½ miles below New Bridge being 1,010 feet.†

The next bridging operation of importance in the Peninsula Campaign occurred at Barretts Ferry, across the mouth of the Chickahominy, on August 13th. The bridge was constructed in connection with the withdrawal of the Army of the Potomac from Haxalls Landing to Fort Monroe.‡

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*Barnard, Reb. Records, S. N. 12, p. 108.
Gilbert Thompson, p. 12.
B. S. Alexander, Reb. Rec., S. N. 12, p. 135.

†Woodbury, Reb. Rec., S. N. 12, p. 198.
Barnard, Reb. Rec., S. N. 12, p. 114.
McClellan, Reb. Rec., S. N. 12, p. 25.

‡Barnard, Reb. Rec., S. N. 12, p. 118.
Ira Spaulding, Reb. Rec., S. N. 95, p. 646.
Barnard, R. R., S. N. 12, p. 121.

The army had lost nearly all its accompanying bridge equipage during the retreat of the Seven Days. To conduct the army by land back to Fort Monroe an ample supply of bridge equipage was necessary. The broad lower Chickahominy lay across the path. It was decided to effect the crossing near the mouth of the Chickahominy at Barretts Ferry.*

Fortunately, the equipage in the depot at Fort Monroe could now be obtained and it was ordered up by water.

General Barnard says:

> The materiel (which consisted of 61 new pontons and 31 old ones) was at Fort Monroe, and it took till the morning of the 12th to get it up to the point mentioned. (Barretts Ferry.)
>
> At noon of the 13th August, the materiel was all unloaded and the bridge commenced at both ends and in the middle—Capt. Spaulding, Fiftieth New York Volunteers, being in charge of the western end, Lieut. Comstock of the middle, and Lieut. Cross of the eastern end; Capt. Duane being in charge of the whole. As the pontoniers had been severely worked during the two preceding days, the operations were suspended during the night and resumed in the morning, the bridge being finished at 9.30 a. m. on the 14th, and a squadron of cavalry crossing at 10.00 a. m.
>
> The bridge was 1,980 feet long. The western end was built by ''successive pontoons,'' the rest by ''rafts.'' At times there was difficulty in maneuvering the rafts from the depth of water and the strength of the tidal currents. After its completion it was covered with straw to prevent the wear of the flooring.
>
> Excepting Heintzelman's Corps, the whole Army of the Potomac, with its artillery and baggage wagons, crossed the bridge. There was no interruption to travel, the only accidents being that a few horses got overboard without injury to the bridge.
>
> The straw proved a perfect protection to the flooring, scarcely a plank being found injured.
>
> The advance guard of General Porter passed on the morning of Friday 15th and at 10.00 a. m. August 18th, the extreme rear guard had passed; and at 2.30 p. m. the boats were all out of the bridge and at 3.00 p. m. all the bridge materiel was in tow of steamers bound for Old Point.

Concerning this crossing, General McClellan writes:†

> Previous to the departure of the troops I had directed Capt. Duane of the Engineer Corps to proceed to Barretts Ferry near

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*Barnard, Reb. Rec., S. N. 12, p. 123.
Gilbert Thompson, p. 21.

†McClellan, Reb. Rec., S. N. 12, p. 90.
Ponton Manual, p. 14.

the mouth of the Chickahominy, and throw across the river at that point a ponton bridge. This was executed promptly and satisfactorily under the cover of the gunboats, and an excellent bridge of about 2,000 feet in length was ready for the first arrival of troops. The greater part of the army, with its artillery, wagon trains, etc., crossed it rapidly and in perfect order and safety, so that on the night of the 17th everything was across the Chickahominy except the rear guard, which crossed early on the morning of the 18th, when the ponton bridge was immediately removed.

This was the longest ponton bridge thus far built by American troops and, indeed, only twice later do we find ponton bridges of greater length. From Fort Monroe the equipage was formed into rafts and towed to Washington.

ANTIETAM CAMPAIGN.

The next bridging of magnitude in the operations of the Army of the Potomac occurred at Harpers Ferry. At the time of the surrender of Harpers Ferry to Jackson (September, 1862), the ponton bridge across the Potomac at that place was destroyed; the material being scuttled, burned or sunk. September 21st, following the Battle of Antietam, the Engineer troops salvaged what material they could and repaired it. Other equipage lately returned from the Peninsula and lying at Washington was shipped by rail under charge of the Fiftieth New York Volunteers, and on the 25th a new ponton bridge was thrown across the river.

On September 27th a bridge of sixteen boats was thrown across the Shenandoah east of Harpers Ferry, near the site of the flying bridge built during the previous March. October 24th a bridge was thrown across the Potomac at Berlin, a village about 10 miles east of Harpers Ferry.* Here the bulk of the Army of the Potomac, under McClellan, crossed from Maryland south into Virginia. The bridge consisted of about sixty-one boats, and remained in place from October 24th to November 12th.

FREDERICKSBURG CAMPAIGN.

The next use of the ponton equipage in the eastern theater occurred during the Fredericksburg Campaign.

On November 7th, 1862, while the bulk of the Army of the

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*Gilbert Thompson, p. 24.
Ira Spaulding, Reb. Rec., S. N. 31, p. 148.
Burnside, Reb. Rec., S. N. 31, p. 62.

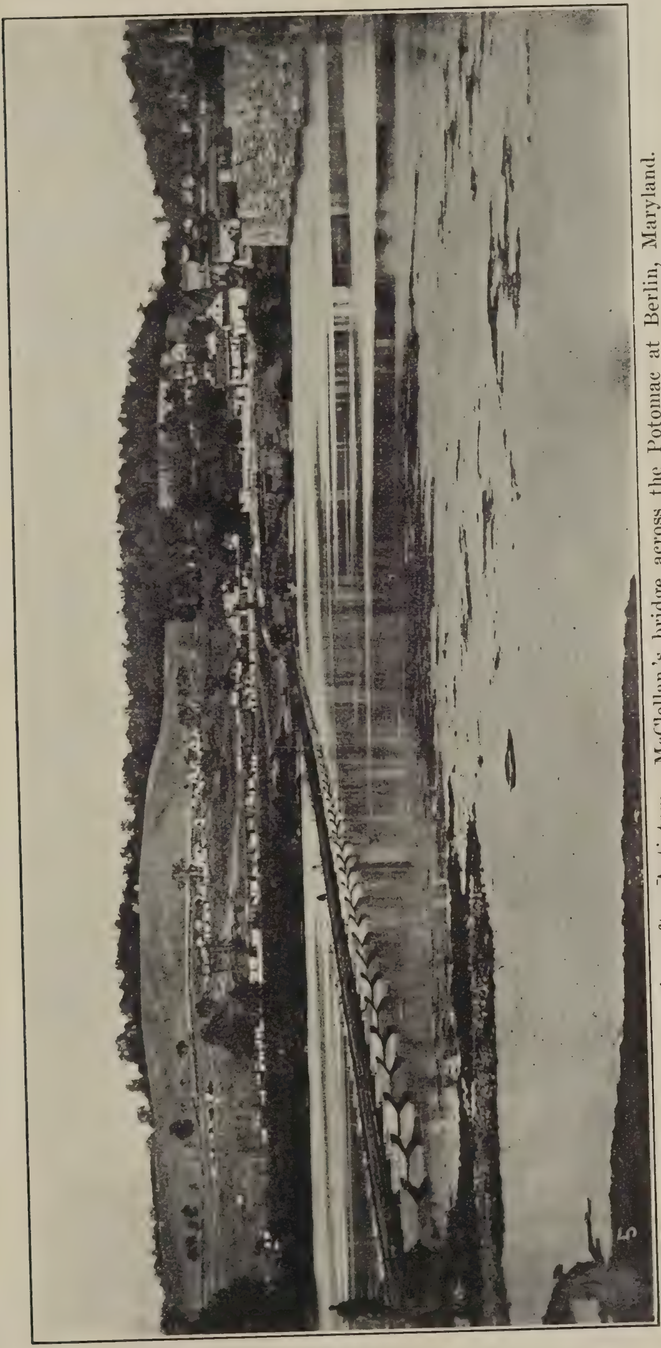

Fig. 1. The Crossing after Antietam. McClellan's bridge across the Potomac at Berlin, Maryland.

Potomac was at Warrenton, Va., an order arrived relieving McClellan, and assigning Burnside to command. With the change of commanders came a change of the plan of campaign. Burnside proposed to concentrate all his force near Warrenton to threaten Culpeper or Gordonsville,* ''then make a rapid march of the whole force to Fredericksburg with a view to a movement upon Richmond from that point.'' To accomplish this plan, bridge equipage was indispensable. There was none at this time (November 7th) with the moving army. Two bridges were in place,† one at Harpers Ferry and one at Berlin. There were a few boats left at this time in the depot at Washington.

For any plan of campaign of the army in Virginia the bridge equipage was a necessity; for Burnside's it was a *sine qua non*. It was charged by Burnside after the Battle of Fredericksburg that the delay in the arrival of the pontons so altered his plans as to be responsible for the loss of the battle.

Congress ordered an investigation of the matter by the Committee on the Conduct of the War, with a view to establishing the facts and the responsibility. That the lack of a ponton equipage could be charged with responsibility for the failure of a campaign merits a close study of the facts by all Engineer officers, and we shall therefore take the time to look into the sources to see what can be established and what lessons may be drawn.

November 6th, Duane, Chief Engineer of the Army of the Potomac, ordered‡ Maj. Ira Spaulding, then at Berlin in command of the Fiftieth New York Volunteer Engineers, to make provisions for maintaining the existing ponton bridge communication at Harpers Ferry; to dismantle the Berlin Bridge; to send all the equipage and the command (less that retained at Harpers Ferry) to Washington; at Washington to make up a land train as speedily as possible and be prepared to march at a moment's notice. This order was not received by Spaulding till the afternoon of November 12th (six days later).

Spaulding executed the order after he received it with the alacrity that characterized all his actions, and by the night of the 13th he himself and a train of thirty-six boats had arrived in Washington. By the night of the 14th the remainder of the equipage was in Washington.

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*Burnside, Reb. Rec., S. N. 31, p. 99.

†Burnside, R. R., S. N. 31, p. 83.
Spaulding, R. R., S. N. 31, p. 148.

‡Spaulding, R. R., S. N. 31, p. 148.
Burnside, R. R., S. N. 31, p. 86.
Woodbury, R. R., S. N. 31, p. 84.

In the meantime, Generals Burnside and Halleck met in conference at Warrenton, November 12th, and discussed the plan of campaign. Halleck tried to influence Burnside to adopt the plan of campaign outlined by Lincoln in a letter to McClellan dated October 13th. This plan was to pursue the army of Lee,[*] keeping close to the Blue Ridge Mountains and thereby being always nearer both Washington and Richmond than was Lee. Burnside, however, stood firm for his own plan of moving on Richmond from Fredericksburg. At the meeting Burnside stated his need for the ponton equipage of the Army, now left behind on account of lack of animal transportation at Berlin and Harpers Ferry. Burnside urged that Halleck have this equipage brought down for use in the passage of the Rappahannock at Fredericksburg.[†] General Meigs, who was present at the conference and was in touch with the ponton situation, drafted the following telegram and suggested that Halleck send it:[‡]

Warrenton, Va., *Nov. 12, 1862.*
7.10 p. m.

Brig. Gen. Woodbury,
Engineer Brigade, 19th & F Sts.,
Washington, D. C.

Call upon the C. Q. M., Col. Rucker, to transport all your pontons and bridge materials to Aquia Creek. Col. Belger has been ordered to charter and send 100 barges to Alexandria.

H. W. Halleck.

Woodbury says he received this wire on the morning of the 13th.[§]

On the night of the 13th Spaulding called on Gen. D. P. Woodbury and showed to the General his orders. Woodbury directed Spaulding to call around the next morning, and after considerable delay and consultation with Halleck, ordered the trains placed in depot near the Navy Yard and the engineer command placed in camp. The command of the army having changed since the date of Duane's orders, November 6th, Spaulding states* that he considered the order to go into depot due to change in plan of campaign.

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[*] R. R., S. N. 31, p. 97.

[†] Conduct of the War, Vol. 1, p. 673.
Burnside, R. R., S. N. 31, p. 84.
Halleck, R. R., S. N. 31, p. 48.

[‡] Conduct of the War, Vol. 1; Woodbury, p. 663; Meigs, p. 678.

[§] Conduct of the War, Vol. 1; Woodbury, p. 663.

On November 14th, Burnside, anxious about the pontons, directed his new chief engineer, Lieutenant Comstock, to wire General Woodbury, asking what news of the pontons. Receiving no immediate reply he sent another, to which Woodbury responded:

Washington, D. C., *Nov. 14, 1862.*

Lieut. COMSTOCK:

I have received your two telegrams to-day. Capt. Spaulding has arrived and 36 pontons have arrived. 40 men are expected in the morning. Capt. Spaulding received Capt. Duane's order of the 6th on the afternoon of the 12th. One ponton train can be got ready to start on Sunday or Monday morning, Nov. 16th or 17th, depending somewhat on the Q. M. D. General Halleck is not inclined to send another train by land, but will allow it, probably, if Gen. Burnside insists. A second train can be sent by water to Aquia Creek, and from thence transported by the teams which carry the first.

D. P. WOODBURY,
Brig. Gen.

Woodbury at this time was commander of the Engineer Brigade composed of the Fiftieth and Fifteenth New York Volunteers, and Spaulding was one of his regimental commanders. The nature of campaigning up to this time must have convinced the veriest tyro that, with any plan of operations whatsoever, an army operating in a country so cut up with rivers as Virginia needed adequate bridge trains at all times. Its lack of adequate communication across the Chickahominy was the basis of Lee's plans to destroy the Army of the Potomac. Again, after the Seven Days' fighting, Woodbury knew that but for an adequate bridge train to cross the Chickahominy at Barretts Ferry, the withdrawal of the army from the Peninsula could not have been effected. Later still, the passage of the Potomac to the southward could not have been effected without bridge equipage. Nevertheless, Woodbury (who, Spaulding says, was on November 13th, living in a house at Washington and not with his brigade) countermanded the orders of the commander in the field to bring up the trains from the rear.

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*R. R., S. N. 31, p. 149.

That Duane was compelled to order his own equipage to rejoin the moving army by rail and canal was due, unfortunately, to the wretched lack of animal transportation with the trains. At that time, instead of having its own animals, thus insuring the commander freedom of tactical decision, the animals were borrowed from the Quartermaster Department as needed for the moment and then returned. But of this, more anon.

Notwithstanding the telegram of Woodbury, it was not earlier than the afternoon of the 15th* or 16th, says Spaulding, that Woodbury directed him to make up his trains. He states he can not remember which afternoon. He was directed to make up two trains of twenty-four boats each to go by water to Belle Plain and a train of twenty boats with transportation for forty, to proceed by land. Before dark of the same afternoon on which the order was received, Spaulding, with his usual promptness, delivered the two trains that were to go by water to the tugboat that took them. These tows, after delays due to grounding, eventually arrived at Belle Plain November 18th. For the land train there had to be drawn over two hundred animals, and the harness, etc., fitted, so that the train did not start till the afternoon of the 19th. It experienced much difficulty of travel, due to bad roads. The travel became so heavy that Spaulding wired for a towboat. The boat arrived promptly at Occoquan Creek and the equipage was formed into rafts and towed to Belle Plain, the animals proceeding by land. Belle Plain was reached the 25th. The train that went by water reached Falmouth from Belle Plain, ready for business, November 24th. Thus the order of November 6th to bring up the bridge equipage did not produce a ponton till the 24th—nearly three weeks later.

In the conference between Halleck and Burnside at Warrenton, above quoted, Halleck declined to authorize Burnside's plan himself, but submitted it to the President on the 13th and wired the President's assent on the 14th.† Halleck insists that in this plan he understood Burnside was to ford the Rappahannock above its junction with the Rapidan, but Burnside states that he meant to go to Fredericksburg, previously having part of his force cross the fords mentioned to uncover the passage over the ponton bridges at Fredericksburg; that the success of his plan depended on the prompt arrival of the pontons, that Halleck agreed to have the pontons forwarded rapidly. The discussion was oral, so no written record is found to establish which statement is correct. Burnside, however, under date of November 9th, submitted a written project* of campaign in which he plainly stated his need in ponton equipage, and he needed it as a matter of fact, whatever might have been his plan; and this, Halleck should certainly have known.

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*Spaulding, Reb. Rec., S. N. 31, p. 149.

†Burnside, R. R., S. N. 31, p. 84.
Halleck, R. R., S. N. 31, p. 47.

Burnside actually arrived at Falmouth, opposite Fredericksburg, on the 17th. Had he been permitted to do so, Spaulding alone could have had a single train with or without its own animal transportation (the one that landed in Washington November 13th) towed by water and at Belle Plain any time after November 14th. Burnside states† that this one train would have been ample for his purposes. As it was, it did not reach Belle Plain till the 18th and then had no animals or wagons with it. By the time the equipage reached the army on the Rappahannock the Confederates were in force across the river, and the opportunity that Burnside planned to seize was gone.

Halleck says:‡

> It was alleged at the time that the loss of the battle resulted from the neglect to order forward the ponton train from Washington. This order was telegraphed by me from Warrenton to Brig. Gen. Woodbury, then in Washington, on the 12th November and was promptly acted on by him. [Woodbury turned away Spaulding on the night of the 13th, after seeing Spaulding's orders, and on the 14th ordered the equipage in depot and the command in camp.—Authors.] Gen. Burnside had supposed that the ponton train was then in Washington or Alexandria, while it was still on the Potomac at Berlin and Harpers Ferry, Gen. Burnside's order to send it to Washington not having been received by the officer left in charge there. Gen. Burnside had only allowed time for transporting his pontons from Alexandria, whereas first they had to be transported to that place from Berlin. The delay was therefore entirely unavoidable and on investigation of the matter by Gen. Burnside, Gen. Woodbury was exonerated from all blame.

The first shipment of thirty-six boats reached Washington from Berlin in twenty-four hours, and yet Woodbury would not yield to the importunity of Spaulding or the telegrams from Halleck of the 12th or Burnside of the 14th, so much as to allow Spaulding to make a water shipment, until the 15th, over forty hours later. Whatever plan Burnside was pursuing, he was certainly entitled to his own bridge equipage and it was peculiarly the duty of Halleck, as Chief of Staff of all the Armies of the United States, to see that everything was done from the rear that might urge forward the prosecution of the fighting plan at the front.

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*Conduct of the War, Vol. 1, p. 643.

†Burnside, R. R., S. N. 31, p. 85.

‡R. R., S. N. 31, p. 48.

Woodbury writes from Key West, December 21, 1863, to Halleck:*

> I have read your interesting report of military operations during the past year and I wish to thank you for all you have said incidentally relative to myself in connection with Burnside's operations at Fredericksburg. I could not fully exculpate myself without demonstrating that my commanding officer, Gen. Burnside, was in fault. The narrative of facts proved this, but some of my friends did not understand the matter and have never been satisfied with my record.
>
> Your clear and explicit statement removes all obscurity and doubt and I am naturally much gratified. My vindication at your hands is the more gratifying, because my own testimony before the Congressional Committee was construed in some of the newspapers as imputing fault to you. When I first met Burnside at Fredericksburg, and was asked to explain why pontons were not at hand when the army arrived, I told him that he commenced his movement before he was ready; that he ought to have remained at Warrenton some five days longer and I added, to show that the idea was not new to me, "I told Halleck so." It never occurred to me to say anything about this conversation to the Committee, nor did I do so or even think of it, until one of them drew it out by a direct question. I seemed then, to a careless reader of the record, to desire to throw some blame on you.

The Committee on the Conduct of the War found† that "the non-arrival of the pontons in time prevented the movement which had been contemplated, and necessitated the adoption of other measures."

They rendered no finding as to responsibility.

The telegram from Halleck, which Woodbury received on the morning of the 13th together with Duane's (McClellan's) order of the 6th, which Woodbury was shown on night of the 13th, together with two telegrams from Burnside of the 14th, all failed to move Woodbury into doing at once what was his plain duty in the first instance without any orders, viz, placing his bridge equipage at the service of his army commander. We believe the record shows that the inexcusable delay in sending forward the bridge equipage operated to thwart the plans of Burnside in such manner as to contribute in a high degree to the disaster at Fredericksburg. Lee might, indeed, have defeated Burnside under any circumstances, but if Halleck and Woodbury had simply at once directed Major Spaulding to act, Burnside could have had a train of equipage on November 17th, with the opportunity to cross in force before the arrival of the bulk of Lee's forces.

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*R. R., S. N. 31, p. 171.

†Conduct of the War, Vol. 1, p. 54.

To the Engineer reader, the lesson is plain. The conditions that made possible the entire deplorable incident with its disastrous consequences were the lack of animal transportation permanently assigned to the bridge train, and the strange inertia of officers whose duty it was to make things move.

The actual bridging at Fredericksburg is a simple story.* Six bridges in all were thrown, and they averaged from 400 to 450 feet in length.

Three bridges were thrown at the upper end of Fredericksburg, one at the lower end, and two a mile farther below. The distance between the outermost bridges was about 2 miles.

Commencing about 3.00 a. m. December 11th, the ponton trains arrived in position on the bank of the river. The construction of four bridges commenced at once, two at the upper end of town, one at the lower end, and one a mile below. The downstream bridge under the regular battalion was pushed to completion practically without interruption from fire and was ready for use at 11.00 a. m.

Those at the town being constructed by the Engineer brigade, under General Woodbury, had been built about half way across when, at 6.00 a. m., a sharp musketry fire was opened on the pontoniers of the lower bridge, under Major Spaulding, and they were driven to cover. There had been placed on the heights opposite the city some seventy-nine guns to cover the crossing. A vigorous artillery fire was now opened on the houses near the bridge head, which were sheltering the Confederate riflemen. About 8.00 a. m., in a similar fashion, fire was opened by the enemy on the upper bridges at the town under Major Magruder, and with similar results. During the morning several unsuccessful attempts were

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*R. R., S. N. 31, Comstock, Woodbury, Magruder, Spaulding, McGrath, Cross, Hunt, pp. 167-183.

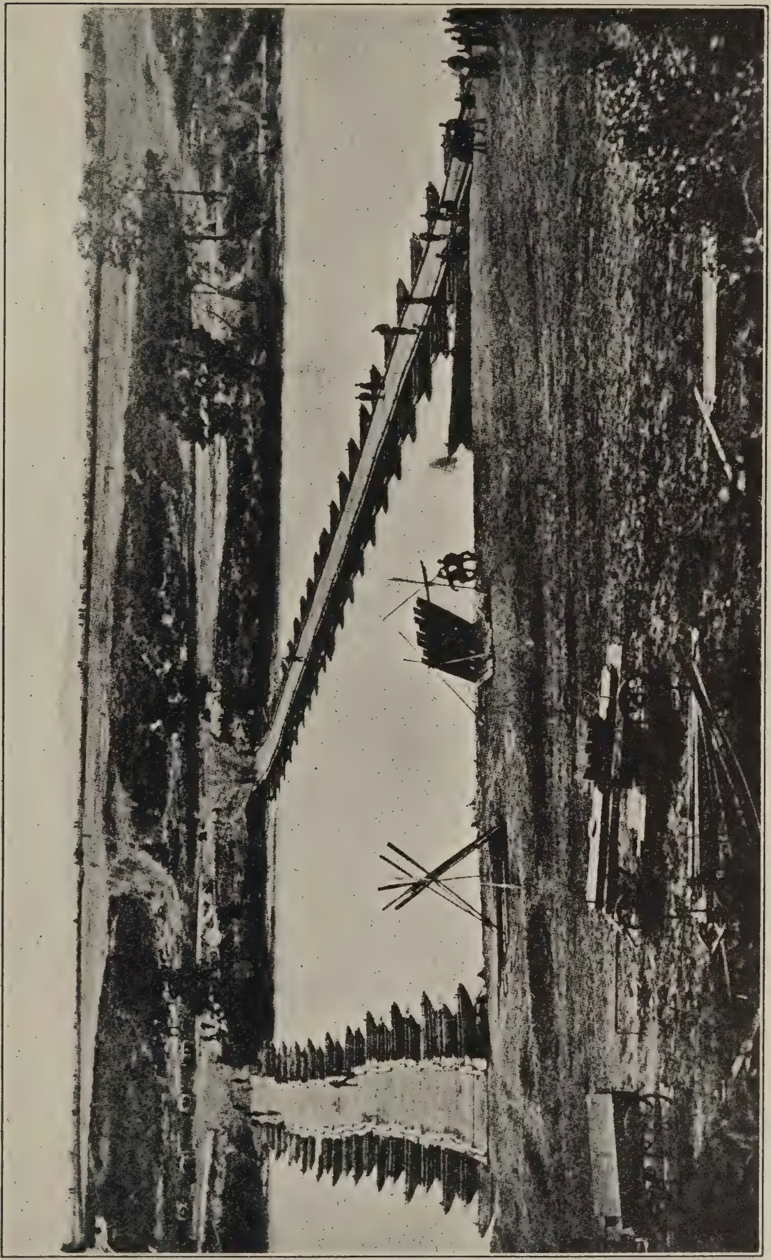

Fig. 2. Pair of bridges across the Rappahannock at "Franklin's Crossing," below Fredericksburg.

made to resume the construction, but the enemy was well sheltered. There was a thick haze all the morning and the artillery fire could not silence the riflemen concealed behind loopholed masonry walls.

About 3.00 p. m., at the suggestion of General Hunt, the Chief of Artillery, detachments were thrown across the river in pontons to dislodge the enemy. At the upper bridge, after a heavy cannonade, 120 men were ferried in six pontons rowed by three men each and they were quickly followed by more. They had no difficulty in driving out the hostile sharpshooters and capturing many of them. At Major Spaulding's bridge, at the lower end of town, 100 men were ferried in a similar manner in four pontons and quickly followed by others. The results were similar to those above.

The construction of the bridges was at once resumed and was completed at dusk. During the night of the 11th and 12th December, another bridge was laid above the town and one near the lowest of all, making thus six bridges, of which five were passable for all arms. The ice in the river hindered the construction considerably.

The total Engineer casualties in the operations were fifty-nine.

After the battle, all the bridges were removed without the loss of any material.

These bridges were built by the Battalion of Regular Engineers and were known as "Franklin's Crossing," from the fact that these bridges were used by the Left Grand Division under Gen. W. B. Franklin, in its passage of the river. After the Battle of Fredericksburg, the Army of the Potomac lay in winter quarters on the north side of the Rappahannock, opposite Fredericksburg. With the exception of the abortive attempt to surprise the enemy by crossing the Rappahannock at Banks Ford above Fredericksburg, known in history as the "mud march," no further hostilities were indulged in till the opening of the Chancellorsville Campaign.

CHANCELLORSVILLE CAMPAIGN.

In the Chancellorsville operations extending from April 28th to May 5th, 1863, the bridge equipage played a controlling part. The plan of campaign was based upon the utilization of large amounts of bridge material.

In all, fourteen ponton bridges were used as shown on page 711.*

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*Gilbert Thompson, p. 33.
Benham, R. R., S. N. 39, p. 215.
Sedgwick, R. R., S. N. 39, p. 557.
Russell, R. R., S. N. 39, p. 592.

No.	Date, 1863.	Under whose direction.	Regiment.	Where laid.	Remarks.
1	Apr. 28	Capt. Lubey	15th N.Y.E.	Kellys Ford, 22 miles above Fredericksburg	Canvas pontons.
2	Apr. 29	Capt. Reese	U. S. Engrs.	Franklin's Crossing, 3 miles below Fredericksburg	Wooden pontons.
3	Apr. 29	Maj. Cassin	15th N.Y.E.	do	Do.
4	Apr. 29	Col. Colgate	do	do	Do.
5	Apr. 29	Lt. Col. Pettes	50th N.Y.E.	Pollocks Mill Creek, mouth 5 miles below Fredericksburg	Do.
6	Apr. 29	Maj. Beers	do	do	Do.
7	Apr. 30	Maj. Spaulding	do	United States Ford, 13 miles above Fredericksburg	Do.
8	Apr. 30	do	do	do	Mixed train.
9	Apr. 30	Col. Colgate	15th N. Y.	Carried to Banks Ford May 1st, but not laid there.	
10	May 3	Lt. Col. Pettes	50th N. Y.	Banks Ford.	
11	May 3	Maj. Beers	15th N. Y.	Fredericksburg, near Lacy House.	
12	May 3	Maj. Cassin	U. S. Engrs.	Do.	
13	May 3	Capt. Reese	U. S. Engrs.	Fredericksburg, near R. R. crossing.	
14	May 4	Col. Colgate	15th N. Y.	United States Ford.	
15	May 4	Lt. Col. Magruder	do	Banks Ford.	

These represent nine different bridges. The remaining five bridges were the same material used subsequently at different places. They varied from 300 feet to 450 feet in length.

The bulk of Hooker's army crossed the Rappahannock by the bridges at United States Ford and Kellys Ford, whilst the lower bridges were used by the corps under Sedgwick (I and VI).

The bridging work was done by the Engineer Brigade, Fifteenth and Fiftieth New York, about 1,400 strong, under Gen. H. W. Benham,* and the Battalion of Regular Engineers, about 300 strong, under Captain Reese.

As yet the bridge trains had no permanent animal transportation assigned them,† but borrowed teams from the Quartermaster Department as occasion arose.

The crossings of the troops under Sedgwick at and below Fredericksburg were executed under the enemy's fire and the operation shows the advantage gained by the experience in the battle of December 11-13, 1862. In the operations of Sedgwick no attempt was made to construct the bridges till sufficient troops had been ferried over to cover the pontoniers at work.

General Sedgwick reports of the crossing as follows:

> On Monday, Apr. 28th, in compliance with the orders of the Commanding General received that morning, the 6th Corps moved to the vicinity of Franklin's Crossing near the mouth of Deep Run, the 1st Corps, Maj. Gen. Reynolds, to a position about one mile farther down the river and the 3d Corps, Gen. Sickles, took position slightly to the rear and between the positions of the 1st and 6th Corps. All the troops encamped that night behind the heights, without fires, and concealed from the observation of the enemy. During the night the pontons were carried by hand to the river. At the upper crossing, and shortly before daylight, Brooks' Division of the 6th Corps crossed in the boats, Russell's Brigade taking the lead, and receiving the fire of the enemy's pickets and reserves. The enemy's rifle pits were immediately occupied, and three bridges promptly laid, under the direction of Brig. Gen. Benham.
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> At Reynold's crossing, one mile farther down, the passage was delayed by a severe fire from the enemy's sharpshooters, but was at length gallantly accomplished, Gen. Wadsworth crossing with a

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*Gen. Benham had relieved Gen. Woodbury in command of the Engineer Brigade.

†Benham, R. R., S. N. 39, p. 214.

Ira Spaulding, R. R., S. N. 95, p. 649.

portion of his division in the boats, and driving the enemy from their rifle pits.

The passage of the troops was successful and showed much smoother work than in the previous instance in December, 1862. The orders from General Sedgwick to Benham required:

> The bridges, two at each crossing, to be laid complete before 3.30 a. m. of the 29th, under the supervision of Gen. Benham, who is charged with the responsibility thereof.

The operation was not carried out precisely as ordered. At the upper crossings, the boats having arrived under cover near the crossings, were to be carried by hand to the river and launched. The crossing detachments were to be told off in advance into small companies duly officered and of such size that each could be ferried by one ponton. Pratt's Brigade was assigned to carry the boats by hand from the wagons to the river bank (in order to avoid alarming the enemy by the noise of the wagons). The crossing force was the Division of Gen. W. T. H. Brooks, Sixth Corps.

General Benham, and General Russell of Brooks' Division, became involved in a discussion as to the distribution of Russell's Brigade into the boats. The Division Commander, Brooks, seemed unable or unwilling to give the necessary orders to untangle the snarl and appeal was made to the Supreme Commander, General Sedgwick. Benham placed Russell under arrest for not complying with orders, but Russell appears not to have recognized Benham's authority. The result was that the ferriage of the river was delayed till daylight (about 4.30 a. m.) and then met with opposition, though the resistance was not very effective.*

Twenty-three pontons were used in this crossing, and as soon as the boats unloaded the men on the south shore, they returned for another load until the division was ferried over. Three bridges were then immediately laid under cover of the fire of Brooks' Division on the south bank. The first was completed by 7.00 a. m. and the last by 8.00 a. m., a delay of some four and one-half hours beyond the time specified in the orders to General Benham.†

General Benham says he expected to carry as many as sixty

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*Benham, R. R., S. N. 39, p. 205.
Brooks, R. R., S. N. 39, p. 566.
Russell, R. R., S. N. 39, p. 591.

†Gilbert Thompson, p. 32.
Benham, R. R., S. N. 39, p. 208.

fighting men per boat in addition to the crews. In the same report, page 206, Benham again refers to his plan to carry fifty to seventy men. General Russell says he divided into companies of forty-five men each for the ferrying.*

It is worthy of notice that in the operations of the combined arms, it is indispensable to success that there be an officer detailed to command the whole operation and that his authority be unquestioned. In the operations against the base of Lookout Mountain in October, 1863, we shall see that Gen. Wm. F. Smith was specially detailed to command the combined forces. In Smith's later movement against the Confederate right at Missionary Ridge, Sherman was present to command in person.

At the lower crossing, near Pollocks Mill Creek, as the pontons were approaching their position, they received some fire from the enemy and the teamsters were thrown into disorder, some abandoning their wagons. There was also friction of command here and interference with the arrangements made for the ferriage at the conference the preceding evening.† At 9 a. m. General Wadsworth's Division was ferried across in a manner similar to that at the upper or Franklin's Crossing. Twenty pontons were utilized in the ferriage at this place. The division without difficulty drove back the Confederates, and under cover of Wadsworth's men, the Engineers (Fiftieth New York, Lieutenant Colonel Pettes) completed two bridges by noon (April 29th).

Throughout the Chancellorsville operations, no bridge material was lost or abandoned to the enemy.

GETTYSBURG CAMPAIGN.

After the Chancellorsville Campaign, the army started north to follow the movements of Lee's army. The Engineer troops with the trains left Falmouth June 13th and moved to Aquia Creek Landing. Here a raft of sixteen pontons was made up and towed to the mouth of the Occoquan Creek to permit the passage of the army across that river. The balance of the equipage on wheels marched overland with the forces. Across the Occoquan, a bridge of fourteen boats was thrown June 14 and the next day, June 15,

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*Benham, R. R., S. N. 39, p. 205.
Russell, R. R., S. N. 39, p. 591.

†Bragg, R. R., S. N. 39, p. 271.
Benham, R. R., S. N. 39, pp. 205-210.
Reynolds, R. R., S. N. 39, p. 253.

a bridge of twenty-seven boats was built across the same stream at Colchester Ferry. The Army of the Potomac passed over these bridges on the 14th, 15th, and 16th. The heavy artillery and the herds of beef cattle passed over the lower bridge at Colchester Ferry. The army having passed, the equipage was taken to Washington, part by water and the remainder by land.

June 17th the equipage was ordered placed on the Chesapeake and Ohio Canal at Georgetown, preparatory to moving northward to bridge the Potomac the second time for the passage of the Army of the Potomac; the fourth time all told. The equipage was at once started on its trip up the canal and traveled all night. On the 18th it reached the mouth of the Monocacy, 42 miles from Washington. On the 19th the rafts were towed down the canal again to Edwards Ferry, 10 miles below the Monocacy. Here the boats were locked into the Potomac and a bridge commenced across that river June 20th. The men were nearly exhausted for lack of sleep. The construction proceeded all the 20th and the bridge was completed at daylight June 21st. The bridge was essentially similar to the one previously built at Berlin. It consisted of sixty-four boats and a few trestles, to make up for a deficiency in boats. In addition to the bridge across the Potomac, another of eleven boats was thrown across Goose Creek near the southern end of the main Potomac bridge. The army had to pass Goose Creek to reach the Edwards Ferry Bridge.

June 25th a second bridge across the Potomac was placed near the first at Edwards Ferry, by the Engineer Brigade.

The Army completed the passage June 27th. Both bridges were dismantled the same day. Some of the boats were loaded on wagons and the remainder were locked up into the canal. July 1st the trains were returned to Washington under a noncommissioned officer.

After the Battle of Gettysburg the hostile armies remained in contact as they proceeded southward. Lee's army crossed the Potomac above Harpers Ferry and moved south up the Shenandoah Valley. The Army of the Potomac now for the third time crossed the Potomac to pursue Lee. This time the crossing was at Berlin. The construction of this bridge is interesting. During the Gettysburg Campaign, the ponton bridge over the Potomac at Harpers Ferry was destroyed, the pontons being scuttled and set adrift above the rapids. On July 15th the Engineer troops salvaged the material and set to work to repair it. The pontons were repaired* with boards and other material at hand and were then placed in the Chesapeake and Ohio Canal and taken to Berlin, 8 miles east of Harpers Ferry. Here, July 18th, a bridge of sixty-one boats was built, over which the entire Army of the Potomac passed south into Virginia.

The hostile armies again confronted each other on the Rappahannock between Warrenton and Culpeper Court-House and for much of the remainder of the year, 1863, there ensued what has been termed the ''Campaign of Maneuvers.'' In this active campaign the armies moved a great deal and the bridge equipage was utilized constantly to pass the Army of the Potomac over the Rappahannock, the Rapidan, and the many smaller streams that drain central Virginia. No long bridges were built at this time, but the epoch was of great importance in the development of the tactical handling of the bridge trains. Heretofore, as has been pointed out in this paper, the movement of ponton equipage from place to place had usually been by water and exceptionally only, by wagon. The armies were now operating in a country much cut up by small rivers, which, while of a size to be formidable obstacles to the movements of armies, were nevertheless too shallow at the controlling points and withal ran in the wrong direction generally to facilitate transportation of bridge equipage from place to place by water.

OPERATIONS IN THE WEST.

Leaving for the time being the Army of the Potomac, let us look at some of the bridge operations, at this time, of the western armies.

Wooden pontons in considerable numbers were assembled in the fall of 1861 on the Ohio River at Cairo for the purpose of bridging that stream. The equipage was entirely without land transportation, and it is probable that the army had at that time no appreciation of the possibilities of mobile bridge equipage. No record is found of the Ohio having been spanned, but the pontons frequently broke loose from their moorings and caused much annoyance to steamboat pilots, with whom the boats were in bad repute.

In Grant's advance on the Confederate line at Henry and Donelson, no bridge material was taken along; nor did the operations up to the surrender of Fort Donelson indicate the necessity of it;

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*Ponton Manual, p. 12.
Gilbert Thompson, p. 41.

though under different circumstances, the separation of Grant's command on two sides of the Tennessee River north of Henry might have had disagreeable results.

Thereafter the western armies came to be supplied with and to use their equipage. Buell's operations in Kentucky and Tennessee in 1862 show a considerable use of ponton equipage of which the mobility, developed by necessity, was much in advance of that of the Army of the Potomac during the same period. The equipage present with Grant's army at Vicksburg was small in amount. There was but one train and it was attached to Sherman's Corps. The use of the equipage* is seen at the crossing of the Big Black River at Bridgeport, east of Vicksburg, May 17, 1863. The train was with Blair's Division of Sherman's Corps.

CHICKAMAUGA CAMPAIGN.

In Rosecrans' advance on Chattanooga, August-September, 1863, he found himself confronted by the formidable Tennessee River. His equipage was quite inadequate in amount and he was compelled to eke it out by many expedients. The bulk of his forces crossed at Bridgeport, Ala., on a make-shift bridge, after much delay, September 4-6, 1863.

CHATTANOOGA CAMPAIGN.

After the Battle of Chickamauga, when the Army of the Cumberland under Rosecrans was besieged by Bragg in Chattanooga, we find the bridge equipage for the first time in the western armies used on a first-class scale. This was due primarily to necessity and next, to the acquisition of Gen. Wm. F. (Baldy) Smith, as Chief Engineer of the Army of the Cumberland.

Bragg's lines entirely invested Rosecrans' on the south bank of the Tennessee River, and compelled the Federal wagon trains to haul their supplies from the base at Bridgeport, Ala., via the long circuitous route over Waldens Range and through the Sequatchie Valley. This necessitated, at the outset, bridging the

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*Sherman, R. R., S. N. 36, p. 755.

Tuttle, R. R., S. N. 36, p. 759.

Sherman's Memoirs, p. 351.

J. H. Wilson, ''Under the Old Flag,'' Vol. 1, p. 205.

The Rebellion Records make no mention of the kind of equipage used at Vicksburg. Sherman, in his Memoirs, says it was the india-rubber equipage. The Brady photos contain a picture which purports to show the bridge. The pontons there shown are not the india-rubber boats, however.

Tennessee River at the intrenched camp in the city of Chattanooga itself. The equipage needed to supply the deficiency of the train with the army was built on the site by the troops, and the river was promptly spanned. Meanwhile, the condition of the besieged army was becoming deplorable. Its wagon trains were largely captured and destroyed by Wheeler's cavalry on the north bank of the Tennessee and the maintenance of the supply by wagon from Bridgeport was difficult in the extreme. Something had to be done to relieve the situation or the army must starve or surrender. Gen. Wm. F. Smith solved the problem. On the 24th of October, 1863, the Corps of Hooker and Slocum were at Bridgeport, Ala., where they had arrived from Virginia. Thomas ordered Hooker's Corps and Gray's Division of Slocum's Corps to cross the Tennessee at that point to the south bank and march through Lookout Valley and Browns Ferry to join the Army of the Cumberland at Chattanooga. Palmer's Division was to be sent via the northern bank of the Tennessee from the beleaguered forces in Chattanooga to Kellys Ferry, there to cooperate with Hooker. For the success of these plans it was necessary to seize the range of hills at the mouth of Lookout Valley covering the Browns Ferry Road. General Smith conceived a plan for effecting this. The plan was approved by General Rosecrans and the preparations were promptly begun. It was necessary to build on the spot the pontons that were to be used, because the material in the Chattanooga bridge could not be released. That bridge had to be maintained. The preparations were practically complete when, on October 20th, the command of the Army of the Cumberland devolved upon Thomas.

Grant arrived the night of October 24th. Smith's plan was submitted to Grant that same night and secured his prompt approval. The plan was as follows: Two brigades, Turchin's and Hazen's, together with three batteries, were told off for the undertaking under command of Smith. Part of the force was to go by land and the remainder by river. The Confederate picket line extended from Missionary Ridge across the valley in which Chattanooga lies, to Lookout Mountain inclusive and beyond. For miles the picket line was along the left bank of the Tennessee River. Fifty pontons were to be loaded with 1,300 men of Hazen's Brigade at Chattanooga and in the stillness of night to be ferried 9 miles downstream to Browns Ferry. The remainder of the command, together with equipage necessary to complete a bridge across the river, were to proceed by land on the north bank of the river to Browns Ferry on Moccasin Point, there to remain in concealment until the arrival of the pontons.

Being still deficient in equipage, by October 24th it was necessary to build about ten pontons and construct a large number of oars within about forty-eight hours. The material was completed on time by the Michigan Engineers and Mechanics, under Captain Fox. The management of the flotilla was entrusted to the Eighteenth Ohio, under Col. T. R. Stanley. His boat crews consisted each of one corporal and four men, a sergeant to command each pair of boats and a commissioned officer in charge of the larger subdivision. Hazen's Brigade was told off into fifty squads of one officer and twenty-four men each. The remainder of the brigade marched by land, under General Turchin. Each squad was equipped with two axes for the purpose of cutting a slashing as a protection immediately on gaining the crest after landing.

Thus each ponton contained thirty men. In all, fifty pontons and two barges were used. The total number of men in the flotilla was approximately 1,600. The brigade and the regiment of boatmen were each thoroughly rehearsed in their duties and the strictest silence was enjoined. The expedition was fortunate in having moonlight to guide them and yet a heavy river haze protected them from easy detection by the pickets on the south bank.

After midnight, October 26th-27th, Hazen's Brigade was awakened and marched to the landing. The details took their places in the boats and shoved off toward the north shore. The flotilla passed through the draw in the ponton bridge at the city. The boats were held till well closed up and then proceeded downstream, sometimes rowing quietly and again drifting, but always hugging the northern shore of the river. They eluded the vigilance of the Confederate pickets on the south shore. Arriving at Browns Ferry the flotilla rowed quickly to the south shore at two separate landings in accordance with orders.

The pickets did not discover the flotilla till it was upon them. The armed men leaped ashore, drove in the pickets, and immediately scrambled up the bank and began to fortify their position by a slashing. The boats then made for the opposite shore where Turchin's Brigade, the remainder of Hazen's men, and the artillery were waiting. These were told off quickly in boatloads and within an hour the entire 5,000 men with artillery were on the south bank and in possession of the crest. The pontons were then assembled into a bridge by Captain Fox. His flooring was waiting at the Moccasin Point end of Browns Ferry. The Confederate artillery endeavored to prevent the construction of the bridge by shelling it. The interference was not serious, however, and the bridge was completed by 4.30 p. m.

Grant says:*

> The remainder of the force (those on the right bank) together with the materials for a bridge, was moved by the north bank of the river across Moccasin Point to Browns Ferry without attracting the attention of the enemy, and before day dawned the whole force was ferried to the south bank of the river, and the almost inaccessible heights rising from Lookout Valley and its outlet to the river and below the mouth of Lookout Creek were secured.
>
> By 10.00 a. m. an excellent ponton bridge was laid across the river at Browns Ferry, thus securing to us the end of the desired road nearest the enemy's forces and the shorter line over which to pass troops if a battle became inevitable. Positions were taken up by our troops from which they could not have been driven except by vastly superior forces, and then only with great loss to the enemy.

In respect to the hour of completion of the ponton bridge, Grant is in error.†

Thomas speaks of this accomplishment as follows:‡

> The recent movements resulting in the establishment of a new and short line of communication with Bridgeport, and the possession of the Tennessee River, were of so brilliant a character as to deserve special notice.
>
> The General commanding tenders his thanks to Brig. Gen. Wm. F. Smith and the officers and men of the expedition under his command, consisting of the brigades of Brig. Generals Turchin and Hazen, the boat parties under Col. T. R. Stanley, 18th Ohio, and the pioneer bridge party, Capt. Fox, Michigan Engineers, for the skill and cool gallantry displayed in securing a permanent lodgment on the south side of the river at Browns Ferry, and in putting in position the ponton bridge on the night of the 26th (26-27) inst.

The total casualties were but four killed and seventeen wounded.§

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*R. R., S. N. 55, p. 28.

†R. R., S. N. 54, p. 78 (Grant did not accompany the expedition).

‡R. R., S. N. 54, p. 68.

§Smith, Hazen, Turchin, Stanley, R. R., S. N. 54, pp. 77-85.

The Federal force now had two long ponton bridges over the Tennessee, one at Chattanooga and the other at Browns Ferry. It shortly became necessary to have a third, and in this wise:

During November, 1863, while the Fifteenth Army Corps under Sherman was marching from Vicksburg on Chattanooga, Burnside, with the Army of the Ohio, was being besieged at Knoxville by a force under Longstreet, who had been detached from the Chattanooga besieging lines for the purpose. It was greatly feared that Burnside could not hold out long at Knoxville against the besieging force. The abandonment of east Tennessee would have been a misfortune for the Federal arms. Grant felt that a diversion at Chattanooga in Burnside's favor was a necessity. He determined therefore on a movement against the right of the hostile besieging line at the north end of Missionary Ridge, with a view to carrying the ridge and threatening Longstreet's line of communication.

General Smith reconnoitered the terrain in the vicinity of the mouth of the Chickamauga Creek and proposed a plan bearing a marked similarity to his previous operation at Browns Ferry. The right of the Confederate line was but thinly guarded by cavalry pickets on the south shore of the Tennessee. It was proposed to move Sherman's troops as they came out of Lookout Valley from Bridgeport, across Browns Ferry Bridge and thence keeping on the north bank of the Tennessee to pass Chattanooga and proceed northeast to a point opposite the mouth of the South Chickamauga Creek. The movement of Sherman's troops would be lost to Confederate view shortly after crossing Browns Ferry Bridge and it could not be told whether they proceeded north on Knoxville or turned east to join the army at Chattanooga.* Pontons were to proceed in advance to a point on the North Chickamauga, a small stream that empties into the Tennessee east of the South Chickamauga. The crossing was to be effected just downstream of the mouth of the South Chickamauga. A small force was to embark in the pontons in the concealment of the North Chickamauga, proceed downstream and into the Tennessee to the designated point. There they were to land, overpower the Confederate picket and secure a foothold on the south shore whilst the pontons promptly ferried over the balance of Sherman's troops, as was done at Browns Ferry. Sherman's troops and the remaining equipage (to throw a bridge across the river) were to be concealed behind high ground within 400 yards of the place of crossing.

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*R. R., S. N. 55, Grant, p. 33; Wm. F. Smith, p. 73; Sherman, p. 573; West, p. 76.

J. H. Wilson's "Life of Wm. F. Smith."

It was planned also to bridge the mouth of the South Chickamauga to permit cavalry operations against the railroads in the Confederate rear. On Monday, November 23d, Thomas' troops drove in the Confederate pickets in the valley of Chattanooga at the foot of Missionary Ridge and captured Orchard Knob. At the same time Sherman's Corps took a concealed position opposite South Chickamauga Creek. One hundred and sixteen pontons were collected in the North Chickamauga by Gen. Wm. F. Smith. Elaborate precautions were taken to guard the citizens in order that no warning of the movements on foot might filter through to the enemy.

The handling of the flotilla was again entrusted to Col. T. R. Stanley. Each ponton was manned by five oarsmen, under a non-commissioned officer. It carried twenty-five armed men. Each group of six boats was under an officer, whose boat was in the lead. Strict silence was enjoined and rowing was not to be resorted to except where necessary.

The brigade of Gen. Giles A. Smith, of Sherman's Corps, was detailed to enter the pontons. The expedition shoved off at midnight, 23-24, and dropped downstream. According to orders, two regiments made a landing upstream of the Chickamauga and the other two on the downstream side of its mouth. They had no difficulty in capturing nearly all the pickets. The pontons darted across the Tennessee to commence ferrying the Fifteenth Corps. The ferrying proceeded vigorously, and by daylight 8,000 men were on the left bank and intrenched behind a *tête-de-pont*.

Lieutenant Dresser, Fourth Artillery, about daybreak began the construction of a bridge across the river. It had been hoped to build a pair of bridges, but the river was in flood and considerably widened so that the equipage was inadequate for two bridges. Dresser worked the bridge from both ends simultaneously and by noon it was completed. Meanwhile, Capt. P. V. Fox, Michigan Engineers, built a 180-foot ponton bridge across the South Chickamauga, thus connecting the regiments of Giles Smith's Brigade. While Dresser's bridge was being built, the steamer *Dunbar* came up in the charge of Gen. J. H. Wilson. She assisted in ferrying the remainder of Sherman's army.

At 1.00 p. m. Sherman moved out and at 3.30 p. m. the Fifteenth Corps had possession of the coveted point, the north end of Missionary Ridge.

The bridge was approximately 1,400 feet in length. Its placing was rendered very difficult by the flood in the Tennessee and the consequent dangerous amount of drift. Two days previous (21st) the flood had carried away the ponton bridge at the city and much of the material was lost. It injured the Browns Ferry ponton bridge seriously, while the Fifteenth Corps was* in the act of passing, and finally the drift and flood caused it to break so that Sherman's rear division had to be left behind with Hooker in Lookout Valley. The bridge was relaid November 24th. At Chattanooga a flying ferry reestablished communication. After planning the movement Smith had to fabricate on the ground material for two bridges, because, as in the case of the Browns Ferry operation, he could not dismantle the Chattanooga bridge, so now he dared not dismantle either of the existing bridges. His shops ran night and day to build the material.

Sherman says of the movement:†

> As soon as the day dawned some of the boats were taken from the use of ferrying and a ponton bridge begun, under the immediate direction of Capt. Dresser,the whole planned and supervised by Gen. Wm. F. Smith in person. A ponton bridge was also built at the same time over Chickamauga Creek near its mouth, giving communication with the two regiments left on the north side, and fulfilling a most important purpose at a later stage of the drama. I will here bear my willing testimony to the completeness of this

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*Sherman says (R. R., S. N. 55, p. 572), " . . . but the bridge broke repeatedly (Browns Ferry ponton bridge) and delays occurred which no human sagacity could prevent." The material of this bridge was built almost entirely by the troops in the field and was in all probability not so strong as similar equipage turned out by the manufacturers. The chief element that threatens the destruction of a bridge in a flood is the drift. If the anchors hold and the cordage is strong, the flood itself can be resisted without great difficulty. Smith reports that when the descent was made at the mouth of the Chickamauga Creek, five rafts were discovered in the Chickamauga, each equipped with a torpedo. The rafts were intended for use by the Confederates as explosive drift, to be turned loose against the Federal ponton bridges. To intercept such rafts, Capt. O. M. Poe at Knoxville used single and even double booms above the bridge and at Chattanooga the flying ferry was ordered to seize them.

R. R., S. N. 55, p. 76.

R. R., S. N. 54, p. 297.

†R. R., S. N. 55, p. 573.

whole business. All the officers charged with the work were present and manifested a skill which I cannot praise too highly. I have never beheld any work done so quietly, so well, and I doubt if the history of war can show a bridge of that extent (viz, 1,350 feet) laid down so noiselessly and well in so short a time. I attribute it to the genius and intelligence of Gen. Wm. F. Smith.

Grant says:*

To Brig. Gen. Wm. F. Smith, Chief Engineer, I feel under more than ordinary obligations for the masterly manner in which he discharged the duties of his position, and desire that his services be fully appreciated by the higher authorities.

The bridge was not, of course, as extensive as the one built at Barretts Ferry the previous year by the Army of the Potomac, nor yet quite so long as the several bridges which had been built over the Potomac, two at Berlin and at Edwards Ferry, and several at Harpers Ferry. The conditions, however, attendant upon the throwing of both the Browns Ferry and the Chickamauga mouth bridges called for boldness and skill which merit the praise given by Grant and Sherman.

Up to the close of 1863, the army at Chattanooga had used a very great number of pontons, most of which were manufactured in the field.† No definite record is found of its using canvas boats. The vigorous use of the equipage at Chattanooga was, however, special in nature. It required very little transportation on wheels. The radius of action was small and time was usually not limited.

ATLANTA CAMPAIGN.

For the 1864 spring advance to Atlanta, new conditions had to be met. A large number of fair-sized streams must be crossed, such as the Chattahoochee, Coosa, and Oostanaula; the army was destined to do an immense amount of maneuvering, the roads were not good. Animals with the army were scarce and it was understood that forage in the region to be traversed was not plentiful.

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*R. R., S. N. 55, p. 36.

†Maj. W. G. Caples, Corps of Engineers, cites from the unpublished correspondence of the Office of the Chief of Engineers a request from Brig. Gen. Wm. F. Smith (place not given), a telegram to Mr. Trowbridge, who was charged with the construction of the bridge equipage at New York throughout the war:

> "Gen. Grant desires me to ask you if you have charge of a canvas ponton train; if so, will you please furnish 150 boats and send the train to the care of Major Simpson, Engineer Corps, Cincinnati."

Major Caples says that an equipage of 600 feet, apparently without wagons, was sent on this order. The writers find nothing in the records of the battles around Chattanooga to indicate its use. The date (Sept. 15) is prior to the Battle of Chickamauga, and while Rosecrans was still in command.

Sherman's forces marched as three armies, the Army of the Cumberland (Thomas), the Army of the Tennessee (McPherson), and the Army of the Ohio (Schofield). The forces moved from the vicinity of Chattanooga for the advance to Atlanta in early May, 1864. Of the great number of wooden pontons whose use at Chattanooga we have been considering, very few, if any, were taken in the advance to Atlanta. The canvas boats alone were used by Sherman's forces from this time on.

Capt. O. M. Poe, the Chief Engineer, writes:*

> Two ponton bridges, having an aggregate length of 1,400 feet, were with the forces in the field and distributed as follows: 800 feet in charge of the 58th Indiana, commanded by Col. Geo. P. Buell, were attached to the Army of the Cumberland; 600 feet in charge of Capt. Kossak, aide-de-camp, and a body of pioneers were attached to the Army of the Tennessee. Both of these bridges were of the kind known as the "canvas bateaux bridge." Two more bridges of the same kind, each 600 feet in length, were held in reserve at Nashville.

This was the first general use of the canvas pontons by the Federal forces operating in the South. Poe states that whenever it was deemed necessary to use a bridge more than forty-eight hours the ponton equipment was replaced by a trestle bridge, improvised from material at hand, in order to save the canvas covers.

Poe says (Chattanooga to Atlanta):†

> In accomplishing these results the engineer department performed the following special labor, viz: 10 ponton bridges built across the Chattahoochee River, averaging 350 feet in length, 3,500 feet; 7 trestle bridges built out of material cut from the bank across the same stream, of which 5 were double-tracked and 2 were single, 350 feet long each, 2,450 feet, 50 miles (estimated) of infantry parapet, with a corresponding length of artillery epaulement; 6 bridges over Peach Tree Creek, averaging 80 feet long

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*R. R., S. N. 72, p. 128.
R. R., S. N. 72, p. 130.
Kossak, R. R., S. N. 74, p. 86.
R. R., S. N. 92, p. 59.

†Reb. Rec., S. N. 72, p. 137.

each, 480 feet; 5 bridges over Flint River, averaging 80 feet long each, 400 feet; also many smaller bridges built and many miles of road repaired.

SAVANNAH CAMPAIGN.

In the march from Atlanta to Savannah, the army moved* in two wings. The ponton train accompanying the right wing was in charge of the First Missouri, five companies, 500 men; that accompanying the left wing was in charge of the Fifty-Eighth Indiana, ten companies, 900 men.

Of the ponton equipage on the march to Savannah, Poe says:†

> Left wing: pontoniers, 58th Ind. Materials, 51 canvas ponton boats, complete, 15 extra covers, 10 anchors, 2,000 pounds rope, 37 horses, 505 mules, 94 wagons, 3 ambulances, 2 tool wagons, 3 forges, 850 chesses, 196 balks, and the necessary harness, etc., to make the outfit complete. This regiment carried its own supplies of subsistence and forage on the wagons in the above list. The length of the bridge that could be built from this train by cutting small timber for the balk was 850 feet.
>
> Right wing: pontoniers, 1st Mo. Materials: 28 canvas ponton-boats complete, 28 boat wagons, 600 chesses, 15 chess wagons, 196 claw balks, 1 forge, 1 battery wagon, 2 tool wagons, 7 forage wagons, and a sufficient quantity of harness, rope, etc. Length of bridge, 580 feet; total length of bridges, 1,430 feet.
>
> The foregoing was the engineer organization and equipment which was considered sufficient to make the campaign, which I knew would be made to Savannah.
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> * * * * * * *
>
> Ponton bridges were built at the following points: over the Yellow River at Railroad Crossing, 100 feet; over the Ulcofauhachee at road crossing, 80 feet; over the Ocmulgee at Planters Factory, 200 feet; over the Little River at railroad crossing, 250 feet; over the Oconee River at Balls Ferry, 300 feet; over the Buffalo Creek on upper Sandersville road, 400 feet; over the Ogeechee River on Louisville road, 200 feet; over the Ogeechee River near Burton Station, 200 feet; over the Ogeechee River, Jones Ferry, 300 feet; over the Buck Head Creek on Millen Road, 100 feet; over the Little Ogeechee near Station 4½; 80 feet; over the Ogeechee at Jenks Ferry, 300 feet; over the Ogeechee at Daltons Ferry, 250 feet; over the Ogeechee at Hiltons Bridge, 300 feet; total, 3,460 feet.

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*Poe, R. R., S. N. 92, p. 59.
Buell, R. R., S. N. 92, p. 160.

†Poe, R. R., S. N. 92, p. 59.
Tweedale, R. R., S. N. 92, p. 560.
Howard, R. R., S. N. 92, p. 65.

Colonel Buell, Fifty-Eighth Indiana, sums his operations on the march to Savannah:[*]

> Corduroyed 2,000 yards, ponton bridge by day 690 feet; trestle bridge by day, 260 feet; trestle bridge by night, 1,030 feet; fascines made, 700; mules, 600; men, 900.
>
> * * * * * * *
>
> My entire command was in better condition when it arrived in Savannah than when it left Atlanta.

Captain Poe says of the canvas pontons:[†]

> Neither of these trains, though frequently used, failed us at any time. Their efficiency became a subject of remark throughout the army. One of these trains (the one belonging to the Right Wing) has been hauled on wagons all the way from Nashville, Tennessee, whence it started April last and it is still (Dec. 26, 1864) in an efficient condition—strong evidence of the durability of the canvas ponton train.

General Howard, commanding the right wing, writes:[‡]

> Much praise is due Lt. Col. Tweedale, 1st Mo. Engrs., for the aid he afforded the Chief Engineer in building wagon and foot bridges across the rivers we met.

General Slocum, commanding the left wing, writes:[§]

> The 58th Ind. Volunteers, Col. George P. Buell, organized as pontoniers, and a portion of the 1st Mich. Engrs., Major J. B. Yates, accompanied my command and were at all times most efficient on the discharge of the arduous duties imposed on them.

CAMPAIGN IN THE CAROLINAS.

In the march from Savannah to Goldsborough,[‖] the pontons of the right wing were in the charge of the First Missouri Engineers and the train of the left wing in charge of the Fifty-Eighth Indiana. The train of the left wing accompanied the army throughout its march, but that of the right wing was transported to Beaufort, S. C., by sea and thence by land with the army.

The right wing built on this march fifteen ponton bridges, aggregating 3,720 feet, and the left wing built 5,490 feet, thus making a total of approximately 9,210 feet.

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[*] R. R., S. N. 92, p. 160.

[†] Poe, R. R., S. N. 92, p. 58.

[‡] Howard, R. R., S. N. 92, p. 74.

[§] Slocum, R. R., S. N. 92, p. 160.

[‖] R. R., S. N. 99, p. 22.

R. R., S. N. 99, p. 138.

R. R., S. N. 98, p. 175.

Lieut. Col. J. Moore, Commanding Fifty-Eighth Indiana, writes of the march from Savannah to Goldsborough:*

> When I started on the campaign my train was made up of very poor mules that were drawn from the convalescent droves at Atlanta, Ga., November last. I have received quite a number of good mules from the two corps, so that my train is in a better condition than when I left Savannah.
>
> My command consisted of the 58th Ind. Volunteers as pontoniers, with an aggregate strength of 650 men, including teamsters and all other men detailed from their respective companies, leaving an average of 500 men for duty during the campaign. I also had in charge a train of 85 wagons and hauled, of ponton bridge, boat and canvas, 1,000 feet, and of other material 860 feet. . . .
>
> Recapitulation of ponton bridging done during the campaign: ponton bridge in length, 5,490 feet; wooden bridge built in length, 1,200 feet. The principal part of this bridging was done after night and over streams that were very rapid and difficult to bridge.

At Goldsborough, N. C., Sherman was joined by Schofield's army and in the movement from Goldsborough to Raleigh the army once more moved in three wings. The ponton equipage was distributed thus:

	Feet, canvas bridge.
Right, First Missouri Engineers	600
Center, Det. Fifteenth New York Engineers	600
Left, Fifty-Eighth Indiana	800
Total	2,000

Shortly after reaching Raleigh, the Confederate force under Gen. Jos. E. Johnston surrendered to Sherman and the right and left wings soon started their march to Washington, D. C.

Poe writes:†

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*Moore, R. R., S. N. 98, p. 426.

Poe, R. R., S. N. 98, p. 175.

Poe's figures respecting the amount of bridging executed by the left wing differ from those given by Moore. Poe gives exact figures for the work of the right wing and general figures only for the left. It is probable at his time of writing, October, 1865, he did not have at hand data concerning the left wing. Moore's report is dated Goldsborough, March 27, 1865, immediately at the close of the march and is probably accurate.

†Poe, R. R., S. N. 98, p. 175.

Upon our arrival at Washington, the ponton trains, which had done us such efficient service, were turned over to an officer designated by the Engineer Bureau. One of them had been hauled on wagons from Nashville, Tenn. via Chattanooga, Atlanta, Savannah, and Raleigh to this city; and the other had in like manner been hauled over the same route from Chattanooga, and they had been in almost daily use for a year with a single renewal of the canvas covers, and were in excellent condition when delivered here. Can any facts go further to show the value of the canvas train in campaigns of the character described? No wooden boats would have stood a moiety of the rough usage bestowed on these. A few days' hauling over the mountains of Georgia, or the corduroy roads of the Carolina Swamps, would have used them up.

Recapitulation* of work done by Engineer troops and troops under Engineer direction, during the campaigns covered by Poe's report.

Campaign.	Ponton bridge built. (*Feet.*)	Trestle bridge built. (*Feet.*)
Atlanta Campaign	3,500	3,330
Savannah Campaign	3,460	1,700
Goldsborough Campaign	7,720	4,000
March to Washington	3,000	----
Total	17,680	9,030

Grant's Campaign of 1864.

During the winter of 1863-1864, the ponton equipage of the Army of the Potomac had undergone considerable changes in design and in organization. At the outset of the Grand Campaign, May, 1864, the equipage with the army in the field was completely wagoned and horsed. It was in the charge of the Fiftieth New York Engineers, Lieutenant Colonel Spaulding. This regiment at the time numbered some forty officers and fifteen hundred men. Company A of the Fiftieth New York, with the remainder of the Engineer Brigade, under General Benham, was in Washington.

The regiment was divided into four battalions and trains were assigned as shown in table, page 730.

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*Poe, R. R., S. N. 98, p. 176.

Battalion.	Cos.	Commander.	Train No.	Composition.
First	B, F, G	Maj. Brainerd	1	14 wooden boats assigned Second Corps.
Second	E, H, L	Maj. Beers	2	13 wooden boats assigned Sixth Corps.
Third	D, K, M	Capt. McDonald	3	13 wooden boats assigned Fifth Corps.
Reserve Battalion	I	Capt. Folwell	4	12 canvas boats with 2 trestles.
	C	Capt. Van Brocklin	5	12 canvas boats with 2 trestles.

The reserve battalion was under the immediate command of Colonel Spaulding. All these trains were arranged under Colonel Spaulding's direction, acting under the general orders of the Chief Engineer, and the whole of the above battalions and trains were to operate under the immediate supervision and inspection of Colonel Spaulding.

The army thus carried with it in the marching column about 1,300 linear feet of bridging. In the advance to Petersburg, the assignment of trains to the army corps was in general preserved, but trains remained under the immediate orders of the Chief Engineer, Major Duane. Tactically, the trains were not under the orders of the several corps commanders, but under those of the chief engineer. The corps commanders did, indeed, naturally issue orders to the trains. They assigned them places in column; frequently they modified or countermanded the orders of the chief engineer for the removal of bridges, until they were satisfied as to the safety of their corps, etc. But the important point for the investigator to note is that the five trains were handled by one man rather than by a number of separate corps commanders.

The canvas trains were of a new model, revised by Major Duane. Some solicitude was felt in advance as to their performance in campaign. They did in fact fulfill every reasonable hope. They had, in 16-foot bays, as much buoyancy per foot of bridge as the wooden boats, and very great mobility. They were, where practicable, used at the heads of columns. The canvas bridge with the advance of a column, having reached a stream, would bridge the stream and pass the troops over. Later, when the wooden train arrived, the latter would lay another bridge and being thus relieved, the canvas bridge would be assembled and expedited again to the head of the column ready to throw the next bridge needed.

The canvas train on several occasions passed from the tail to the head of long columns of all arms on the Virginia country roads.*

The canvas trains were generally used† with columns of cavalry or where speed was urgent.

After the Battle of Spottsylvania, the three wooden trains were reduced to eight pontons each. The surplus material was turned in to depot. The experience from the opening of the campaign up to May 16th, had indicated that generally a train of eight wooden boats would bridge any of the streams to be encountered as far as the James. Presumably, the value of the surplus boats was re-

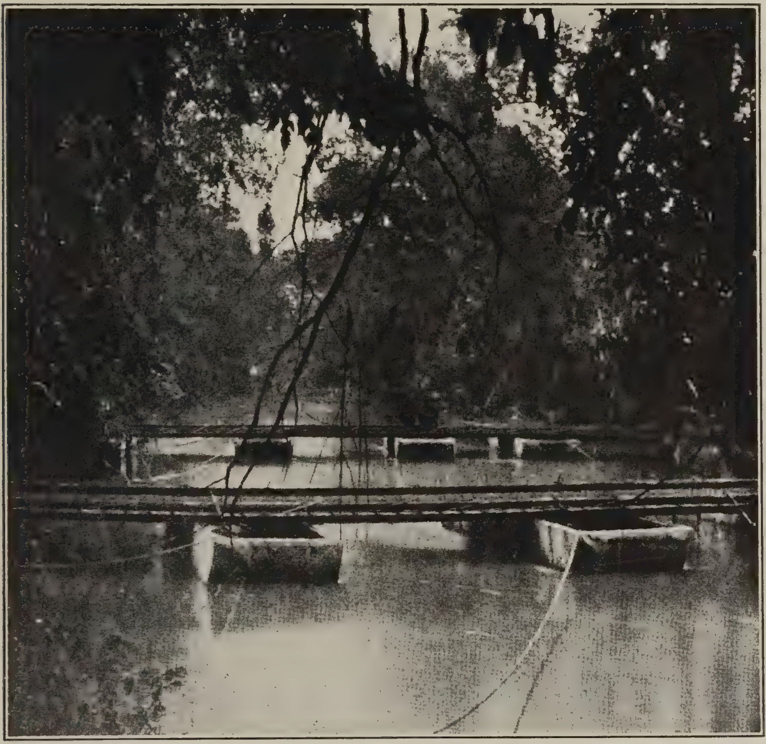

Fig. 3. Canvas bridges across the North Anna, used by Hancock's Corps in the "Grand Campaign."

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*R. R., S. N. 67, p. 310.

†R. R., S. N. 67, pp. 304, 305, 311, 312, 314.
R. R., S. N. 95, pp. 645, 646.
Spaulding, R. R., S. N. 95, p. 159.

garded as not justifying their transportation and road space under the circumstances.

On June 5th Lieutenant Henderson, of the Fifteenth New York, reported at Cold Harbor from Port Royal with a train of twenty boats. Some of this equipage was distributed to the other trains and the balance constituted an additional train accompanying the armies.

In the meantime, General Benham, with the remainder of the Engineer Brigade, the Fifteenth New York and Co. A of the Fiftieth New York, moved from Washington, D. C. to Fort Monroe, carrying* an immense reserve of bridge equipage and siege material. In the fifth epoch of the Grand Campaign (Chickahominy to James, inclusive, including the July assaults on Petersburg). two noteworthy bridges were constructed at the same time. The first was thrown across the Chickahominy at Coles Ferry on the outer flank of the Federal Army in its flank movement to the south of Richmond. Its purpose was to permit the passage of the immense trains of the army and the beef cattle, together with their escort. The four corps of the army had crossed the Chickahominy at Longs and Jones bridges, where the river was not wide. It was intended to pass the trains over the Chickahominy at Windsor Shades, but that proved impossible and the next available place was at Coles Ferry. The river at Coles Ferry was some 1,200 to 1,300 feet wide.

The various corps having passed south of the Chickahominy by the 14th of June, all the land pontons were that day concentrated at Coles Ferry, and the stream bridged. This required the entire equipage on wheels with the army (less a train of eight boats then with Sheridan on his Trevilian Raid). Even then the canvas portion of the bridge was built with extended intervals. The work was completed after midnight June 14-15. Total length, 1,240 feet, with some 450 feet of timber and corduroy approaches. The trains and the cattle under guard of Ferrero's Division at once passed the bridge without accident.†

Meanwhile, the army was moving on the James in the attempt to reach the south side of Richmond. General Weitzel, Butler's Chief Engineer, on June 13th reconnoitered the James for a

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*Benham, R. R., S. N. 67, p. 303.
R. R., S. N. 80, p. 295.

†Spaulding, R. R., S. N. 80, p. 298.
Ferrero, R. R., S. N. 80, p. 594.

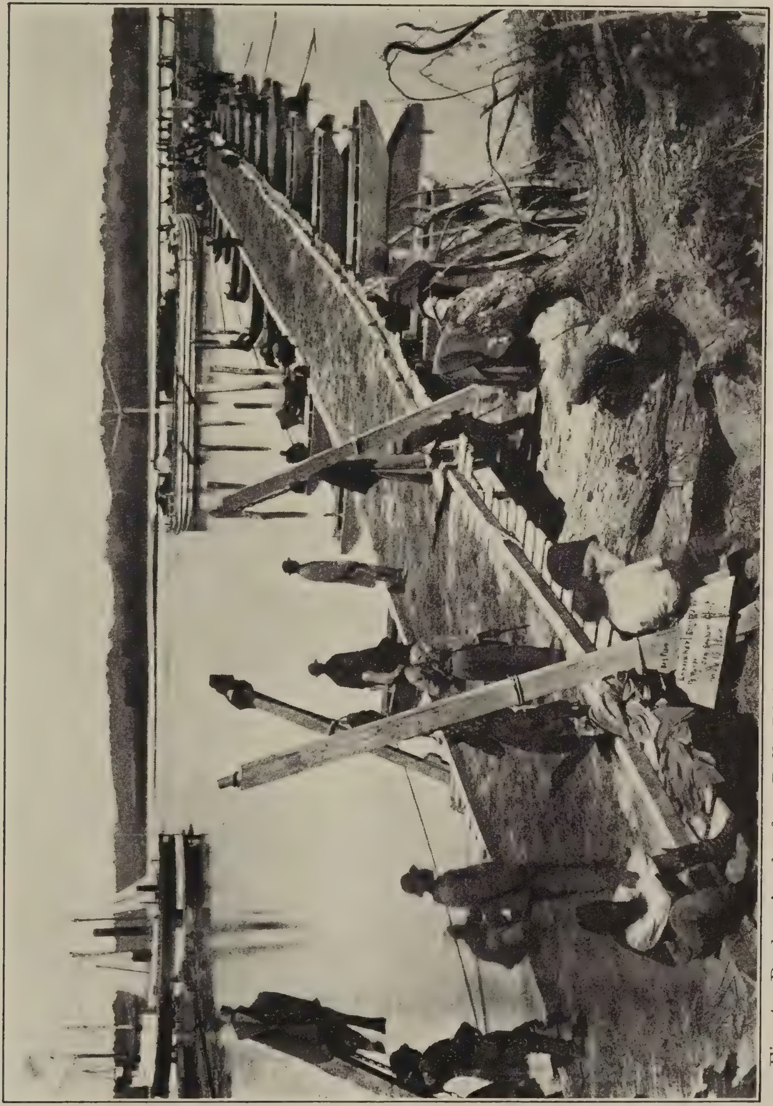

Fig. 4. Benham's wharf at Belle Plain, one month before his famous bridge across the James River.

suitable place to throw a bridge. He decided on a site south of Charles City, near Fort Powhatan. General Butler at Bermuda Hundred, commanding the Army of the James, was directed to turn over his equipage to General Benham who, with the remainder of the Engineer Brigade (Fifteenth New York and one company of the Fiftieth New York) and a great floating train of equipage had just arrived at Fort Monroe from Washington. General Benham was directed to send sufficient equipage to the point of crossing and to construct the bridge. The battalion of U. S. (Regular) Engineers (who up to this time in the Grand Campaign had not been charged with any equipage) were sent to the designated point to commence the bridge.

Captain Gillespie started the approaches on June 13th, and was assisted on June 14th by the U. S. Engineer Battalion. The pontons arrived from Fort Monroe in tow of a steamer, June 14th. The bridge was thrown* between the hours of 4 p. m. and 11 p. m. June 14th. It was constructed from both ends. The bridge contained 101 wooden pontons. It was some 2,200 feet long, longer than any other ponton bridge ever built on this continent before or since. It was constructed wholly of the floating reserve equipage not accompanying the armies in the field. It had no wagon or animal transportation.

The organization charged with the wheeled bridge equipage accompanying the armies (Fiftieth New York), took no part in the construction of the Powhatan Bridge. They were at the very time engaged upon the Coles Ferry Bridge. It is odd that the need for two maximum sized bridges should occur the same day, though not on the same stream.

The construction of the bridge is described by General Benham, the officer in charge. Writing to the Chief of Engineers a week after the work was done, he says:

Headquarters Engineer Brigade,
Camp at City Point, Va.,
June 24, 1864.

General R. Delafield,
Chief of Engineers.

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I presume you will be glad to hear of the success of our ponton

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*Michler, R. R., S. N. 80, p. 289.
Mendell, R. R., S. N. 80, p. 301.
Benham, R. R., S. N. 81, pp. 4, 5, 23, 24.
Gilbert Thompson, p. 68.

bridge, over 2,000 feet long, over the James River just above Fort Powhatan, which I had placed there on the evening of the 15th inst. by the troops under Captain Mendell and Lieut. Gillespie, of our corps, about 200 men, and two companies of the Fifteenth New York Volunteer Engineers, under Captains Lubey and Henderson, and a fractional company of the Fiftieth New York Engineers, under Captain Robbins, 250 volunteers, or in all 450 men.

On the 13th and 14th, in accordance with an order of Gen. Grant, I had sent up the ponton rafts from Fort Monroe under the above-named volunteer troops, not feeling then at liberty under the previous orders of Gen. Meade to leave my other property and troops to go up myself. But about 11.00 a. m. on the 15th I received the order, and was under way in half an hour, arriving at the position selected at about 5.00 p. m. There I found Gen. Meade and Gen. Weitzel, which latter had prepared the approaches and had the abutment commenced. I was at once directly charged with the laying of the bridge by Gen. Meade with the regulars to assist the volunteers, and he smiled when I told him I should not sleep till the bridge was laid.

I distributed my men at once, the regulars at the east end, the volunteers at the west end, and a company of volunteers to prepare a raft by my plan of simultaneous bays.

At about 10.30 p. m. I received a dispatch from Gen. Meade asking the progress of the bridge, to which I was able to reply at once that the last boat was in position, and the raft of three boats built ready to close the gap he had ordered left for the present, and that it was ready for completion in fifteen minutes at any time he ordered.

The gap was closed, but the bridge was not required or used till 6 a. m. the next morning, when the regulars were relieved and the bridge continued under my care with the volunteers, who carefully watched and repaired it every hour or oftener for the seventy-five or eighty hours it was down.

For the next forty hours after 6 a. m. of the 16th, a continuous stream of wagons passed over the bridge (from 4,000 to 6,000 wagons), some said fifty miles of wagons—and nearly all the artillery of this army, and by far the larger portion of the infantry and all its cavalry present, and even to its herd of 3,000 or more of beef cattle (the most injurious of all) without an accident to man or beast.

My officers and men were scarcely allowed any sleep during this time nor myself as much as four hours in the eighty hours preceding the taking up of the bridge, for it was in anxiety, not to say trembling, that I saw the destinies of the whole army of our country even committed to this single, frail, boat bridge, with steamers and other boats drifting against it and with much of its planking previously worn almost entirely through by careless use upon the Rappahannock, and I dared not stop the living stream of men or matter to sheath or protect it.

At length by 7 a. m. on the 18th, the last animals were over and I breathed free again, and although the shelling of our troops across the river just before sunset within a mile above us gave us little hope of withdrawing the bridge in safety, it was ordered up and all rafted into three tows before 3 a. m. of the 19th, and on its way to this point, which it reached about sunrise, the most successful effort on a large scale with ponton bridging that has ever occurred in our country, if it does not rival those in any other land.

The bridge built over the Chickahominy by this same brigade about two years since was nearly as long as this, but built over a comparatively quiet and shallow stream—at least for nearly its whole extent—and with a great portion on trestles, and it was for but a small portion of one or two corps only of McClellan's army, while this bridge, besides some 200 feet of trestle-work, was for over 2,000 feet in pontons, and for the greater part of the distance in deep water, in some parts up to 85 feet, with a very strong current running for a great part of the time, and it transported nearly all the material, artillery and trains with the greater portion of the men of this large army.*

You may be sure I was very well content and satisfied and felt like "him that putteth off his armor" when the affair was over.

W. H. Benham,
Lieut. Col. of Engineers and
Brigadier General.

The Powhatan Bridge was removed after the passage of the beef cattle and the rear guard, June 18th.

A portion of it was then towed up the James,† and on June 20th a bridge of about 600 feet was thrown across the James from Jones Neck to Deep Bottom by Captain Lubey, Fifteenth New York.

The Fiftieth New York alone, during the period from April

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*General Benham is not accurate in his statements as to the troops that passed over these two bridges. The records show that all the foot troops of McClellan's army, with the exception of Heintzelman's Corps, passed over the Barretts Ferry bridge (the one over the Chickahominy to which General Benham refers). On the other hand, out of fourteen infantry divisions (II, V, VI and IX Corps) but five passed over the Powhatan bridge.

Barnard, R. R., S. N. 12, p. 118.

McClellan, R. R., S. N. 12, p. 90.

"The Passage of the James River by the Army of the Potomac, 1864." McDonough and Bond, Army Staff College, 1913. (Compiled from R. R., S. N. 80.)

†Lubey, R. R., S. N. 81, p. 435.

Benham, R. R., S. N. 81, p. 213.

29th to June 23rd, built thirty-eight ponton* bridges of a total length of 6,458 feet. This does not include the Powhatan or Deep Bottom bridges. Twenty were canvas ponton bridges, seventeen wooden, and the Coles Ferry of both types.

When the armies were before Petersburg in July, 1864, the ponton trains were reorganized as follows:†

Trains.	1	2	3	4	5	6
Wooden pontons, number	15	15	14	-----	-----	-----
Canvas pontons, number	-----	-----	-----	12	12	13
Wing trestles, number	-----	-----	-----	2	2	2
Length of bridges, feet	320	320	300	252	252	348

The consolidated length of bridges given above lay between 1,572 and 1,900 feet, depending upon the use of long or short spans in the canvas boats. These trains were completely equipped with transportation. This distribution (with some modifications) was retained to the close of the Appomattox Campaign.

FRANKLIN-NASHVILLE CAMPAIGN.

In September, 1864, following the capture of Atlanta, Sherman decided to move to Savannah with the bulk of his army. As a part of this project, he ordered Thomas and Schofield back to Tennessee to guard that region against hostile movements of Hood. No bridge equipage was returned with these commands. The trains with Sherman, it will be recalled, were exclusively canvas pontons, but there was an immense number of wooden boats left in Chattanooga from the previous year. It soon became evident that Hood intended, not to follow Sherman, but to attack the Federal troops in Tennessee. All troops in the vicinity were thereupon placed under command of Thomas, and he set about to organize his scattered fragments into an army.‡

On November 23rd he directed Col. W. E. Merrill, commanding the First U. S. Veteran Volunteer Engineers at Chattanooga, to organize from that regiment, which was over 1,200 strong, a battalion of pontoniers. Merrill reported that he then had at Chattanooga 1,200 feet of wooden ponton equipage and 240 feet of canvas. Thomas ordered a bridge train built at Nashville; the exact size of which is not disclosed in the records. The train and its organization of pontoniers was not completed at the time of the Battle of Franklin.*

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*Spaulding, R. R., S. N. 67, p. 316.

†Spaulding, R. R., S. N. 80, p. 300.

‡R. R., S. N. 93, pp. 1000, 1134.
R. R., S. N. 94, p. 131.

The battalion of pontoniers ordered created out of the First Veteran Volunteer Engineers was held at Chattanooga by Thomas' orders, and took no direct part in the Franklin-Nashville Campaign. It received orders, December 25th, to bridge the Tennessee at Decatur to maintain communication with Steedman's pursuing column subsequent to the Battle of Nashville. Steedman had crossed the Tennessee on transports. The bridge was laid at Decatur, January 3d.†

The train created at Nashville was of canvas boats. It was organized after a fashion and was ready for use at the Battle of Nashville.‡ During the three days of the battle proper, December 15-17, 1864, there was no use for pontons, but in the pursuit of Hood's forces there was a great need for them. Wilson's Cavalry Corps and T. J. Wood's Fourth Corps led in the pursuit.§

These two bodies pressed forward with extraordinary vigor on parallel roads, the cavalry on the Granny White Road and the Fourth Corps on the more direct Franklin Pike. All went well till they encountered the Rutherford Creek.

Thomas says:‖

> On arriving at Rutherfords Creek the stream was found to be impassable on account of high water, and running a perfect torrent. A ponton bridge hastily constructed at Nashville during the presence of the army at that place, was on its way to the front,

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*Merrill, R. R., S. N. 94, p. 131.
Thomas, R. R., S. N. 94, p. 131.

†Merrill, R. R., S. N. 93, p. 346.
Whipple, R. R., S. N. 93, pp. 345, 353.
Granger, R. R., S. N. 94, p. 480.
Cruft, R. R., S. N. 93, p. 513.

‡Wood, R. R., S. N. 93, p. 136.
Thomas, R. R., S. N. 93, p. 41.
Merrill, R. R., S. N. 93, p. 1000.
Stone: "Battles and Leaders," Vol. IV, p. 456.

§Thomas, R. R., S. N. 93, p. 41.
Wood, R. R., S. N. 93, p. 134.
Wilson: "Under the Old Flag," Vol. II, p. 134.

‖R. R., S. N. 93, p. 41.

but the bad condition of the roads, together with the incompleteness of the train itself had retarded its arrival. I would here remark that the splendid ponton train properly belonging to my command, with its trained corps of pontoniers, was absent with Gen. Sherman.

Nevertheless, both Wilson and Wood managed to cross part of their troops over Rutherford Creek by bridges of circumstance and proceeded south to Duck River, reaching there December 19th. This river was absolutely impassable* to them and they were obliged to await the arrival of the bridge train. The train reached Rutherford Creek December 21st, and immediately bridged it.† Part of the train not used was sent ahead at once to Duck River. It reached the latter place on the night of December 21-22, and early on the 22d the stream was bridged and Wilson's and Wood's corps crossed. The delay involved was two days.‡

Wilson says:

> Meanwhile the only ponton train belonging to the army had been sent on the wrong turnpike by someone whose name was never known. But as it did not get back to the direct road nor overtake my leading division for 48 hours, the result was that two whole days and nights were lost. With one raging creek (Rutherford) and one river (Duck) out of banks to bridge and cross, it was now certain that Hood would gain sufficient time to save the wreck of his army and get well on toward Alabama before we could possibly get strung out again in orderly pursuit.
>
> Much has been said first and last in condemnation of Thomas for letting this ponton train go astray, and it was certainly a grievous mistake, whoever made it, but it may well be doubted, even if we could have laid the bridges one after the other and got across the two streams, whether we would have been in time to bring Hood to bay or to interfere materially with his safe retreat from Columbia to the Tennessee River.

The pursuit of the Confederate army, after Nashville, was the most brilliant example afforded by the Civil War of a pursuit after a battle. The world's military history scarcely shows a better example. It seems, then, ungrateful to expect of Thomas more

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*Thomas, R. R., S. N. 93, p. 42.
Wood, R. R., S. N. 93, p. 135.
Wilson, R. R., S. N. 93, p. 566.

†Wilson, R. R., S. N. 93, p. 566.
Thomas, R. R., S. N. 93, p. 42.
Wood, R. R., S. N. 93, p. 136.

‡"Under the Old Flag," Vol. II, p. 135.

than he actually accomplished in the campaign. For ten days after the close of the battle proper, Thomas' leading troops continued close on the heels of the fleeing Confederates, and this amid the most trying conditions of mud, ice, overflowing rivers and scarcity of rations and forage. If the bridge train had been handled more fortunately, however, the results of the pursuit would likely have been greater still. On November 23d, Thomas directed Merrill to organize one of his battalions as a pontonier battalion; November 28th, Thomas wired Merrill to hold the battalion in readiness at Chattanooga. December 10th, Merrill asked if Thomas desired the battalion sent to Nashville, and the latter replied in the negative.* The record does not disclose of what men the pontoniers were made up or where the animals were obtained or the total size of the train. There is evidence that the men were not skilled, however. Thomas probably wanted the Chattanooga regiment to be employed in bridging the Tennessee, but it might have been better had he taken one battalion of the regiment to Nashville in November. This trained battalion would doubtless have pushed the construction of the train more skilfully and handled it in the field more intelligently. Wilson is the only one who is found to state that the bridge train was shunted off on the wrong road. The roads were in desperate condition, but not so bad as to prevent the speedy approach of the train from Franklin south to Duck River.

The campaign shows a deficient bridge equipment hastily thrown together and probably lacking in specially trained officers. For a pursuit so brilliantly conducted as this one, it is specially desirable that the bridge train be well organized and skilfully handled.

Thomas' views regarding his deficiency in ponton equipage and other transportation and his feeling that Sherman was largely responsible for the shortage, is illustrated by the following correspondence.†

Washington, *December 21, 1864.*

Major General THOMAS:

Permit me, General, to urge the vast importance of a hot pursuit of Hood's army. Every possible sacrifice should be made, and your men for a few days will submit to any hardship and

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*Merrill, R. R., S. N. 94, p. 131.
Thomas, R. R., S. N. 94, p. 131.
Thomas, R. R., S. N. 93, p. 1000.

†R. R., S. N. 94, p. 295.

privation to accomplish the great result. If you can capture or destroy Hood's army, Sherman can entirely crush out the rebel military force in all the Southern States. He begins a new campaign about the first of January, which will have the most important results, if Hood's army can now be used up. A most vigorous pursuit on your part is therefore of vital importance to Sherman's plans. No sacrifice must be spared to attain so important a result.

Hdqrs. Department of the Cumberland,
In the Field, *December 21, 1864.*

Maj. Gen. H. W. Halleck,
Washington, D. C.:

Your despatch of 12 m. this day is received. Gen. Hood's army is being pursued as rapidly and as vigorously as is possible for one army to pursue another. We cannot control the elements, and you must remember, that to resist Hood's advance into Tennessee I had to reorganize and almost thoroughly equip the force now under my command. I fought the battles of the 15th and 16th instant with the troops but partially equipped, and, notwithstanding the inclemency of the weather and the partial equipment, have been enabled to drive the enemy beyond Duck River, crossing two streams with the troops, and driving the enemy from position to position, without the aid of pontons, and with but little transportation to bring up supplies of provisions and ammunition. I am doing all in my power to crush Hood's army, and if it be possible will destroy it; but pursuing an enemy through an exhausted country, over mud roads, completely sogged with heavy rains, is no child's play, and cannot be accomplished as quickly as thought of. I hope, in urging me to push the enemy the Department remembers that General Sherman took with him the complete organizations of the Military Division of the Mississippi, well equipped in every respect as regards ammunition, supplies and transportation, leaving me only two corps, partially stripped of their transportation to accommodate the force taken with him, to oppose the advance into Tennessee of that army which had resisted the advance of the Army of the Military Division of the Mississippi on Atlanta, from the commencement of the campaign until its close, and which is now, in addition, aided by Forrest's cavalry. . . .

THE CAPACITY OF THE EQUIPAGE.

The recital of the performance of the equipage in the various campaigns of the Civil War is sufficient to show that it was capable of sustaining the traffic imposed upon it. Very few are the reports of breaks or failures and there are no reports showing that the tactical success of the commander was jeopardized. On the occasion of the passage of Sherman's Fifteenth Corps over the Tennessee at Browns Ferry, when the river was in flood and carrying much drift, the bridge broke repeatedly, yet it was as often repaired. The bridges in the northern rivers withstood the strain of floods as violent as those of the Tennessee, without breaking. The reason for the breaks in the Tennessee bridges lies, probably, as stated above by Sherman, in the fact that the equipage was constructed in the field. The details of the breaking are not given, but probably the hawsers were parting. Capt. O. E. Babcock reports his manufacturing rope at Knoxville.* He also reports that he was manufacturing cables out of telegraph wire. Such homemade cordage and improvised cables, of course, could hardly be expected to stand high tensile tests, and if these or similar hawsers were used at Browns Ferry it is not surprising that breaks occurred.

Colonel Moore, Fifty-Eighth Indiana, reports that he built a bridge 660 feet long over the Catawba, in South Carolina, February 22, 1864, for the passage of Sherman's left wing. After the bulk of that wing had crossed, heavy rains swelled the Catawba to a torrent and carried away 400 feet of the bridge. The bridge had been laid just below the rapids, while the river was at a low stage. When the river rose to flood height, the position below the rapids was perilous. The bridge was next day, February 26th, relaid 500 yards farther downstream. No interference with the march of the troops resulted because they were delayed by muddy roads. No reports are found of breaks in the large Potomac bridges. In February, 1862, as shown above, a bridge was thrown while the Potomac was a torrent.† The bridge withstood the flood without a break. The material at that time was new and of standard shop manufacture.

The bridge at Coles Ferry was so long that the canvas boats had to be laid with extended intervals, the bridge thus being much weaker. All the trains and the beef cattle of the army (the heaviest test loads) passed without accident.

Colonel Spaulding reports‡ that May 28, 1864, Captain Folwell built a canvas bridge of 146 feet across the Pamunkey at Mrs.

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*Babcock, R. R., S. N. 56, p. 77.
Sherman, R. R., S. N. 55, p. 572.

†Ponton Manual, p. 13.
Gilbert Thompson, p. 6.

‡R. R., S. N. 67, p. 312.

Nelsons Crossing; that owing to scarcity of material, Folwell was compelled to build the bridge "in long spans of 21 feet, the balks alternating on the gunwales, and over this seemingly frail bridge passed without accident two divisions of the Sixth Corps with their artillery."

This is valuable testimony to the strength and the adaptability of the equipage.

The strength of the bridge in the case of these extended intervals can be conserved by using the side rails as extra balk and substituting for the side rails saplings cut on the site.

The bridge across the James at Fort Powhatan was subjected to a great current and a tidal range of 4 to 5 feet in a depth as great as 80 feet. It was secured to schooners anchored up and down stream and on one occasion the bridge was broken by a ship crashing into it. It was repaired at once without evil consequences.

Many times the fate of the army truly depended upon the stability and the capacity of the bridge equipage and the trust was not misplaced.

General Barnard says:*

> The numerous proposers of "flying bridges" forget that if a military bridge is intended to be *carried with* an army, it is also intended to *carry* an army, its columns of men, its cavalry, its countless heavy wagons, and its ponderous artillery. It must carry all these, and it must do it with certainty and safety even though a demoralized corps should rush upon it in throngs.
>
> No make-shift expedient, no ingenious invention, not tested by severe experiment, no light affair of which the chief merit alleged is that it is light, will be likely to do what is required and what the French ponton has so often done.

The Ponton Manual states:†

> Thus the wooden ponton trains, through four years of war, during which the bridges constructed were without parallel in number and magnitude, amply fulfilled all the requisites of a good bridge equipage. The frequent crossing of the Chickahominy, Potomac and James rivers proved that, even under the most

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*Barnard, R. R., S. N. 12, p. 128.

†Page 15. The Ponton Manual was written by Lieut. Col. J. C. Duane, Maj. H. L. Abbot, and Maj. W. E. Merrill. It was approved by Maj. Gen. A. A. Humphreys. All were principal actors in the Civil War and were peculiarly well qualified for the task. In the Ponton Manual they recorded, while events were still fresh in their minds, the accumulated bridging experience of the Civil War.

unfavorable circumstances, they could furnish a bridge capable of passing a large army with its heaviest trains over wide and rapid streams with safety and despatch.

It is believed that the record amply justifies the above statements.

THE PONTON AS A FERRY OR INDIVIDUAL CRAFT.

Reviewing the ferrying operations throughout the war, we see some striking cases. At Eltham Landing on the York River, May 7, 1862, Franklin's Division of some 8,000 troops were ferried ashore the short distance from the transports that carried them in the brief space of less than three hours.*

B. S. Alexander says that two thousand men were carried at a time, exclusive of the oarsmen. He had about seventy pontons, therefore it is inferred that the boats carried from twenty-five to thirty passengers each. Following this, the boats were made up into rafts for the ferriage of horses and of some artillery and later, still, they were used to form the wharf piers to permit the landing of artillery, wagons, and supplies. For pier heads, in this instance, canal boats were used and the bridge equipage constituted the pier proper.

At Fredericksburg, we have seen† that when the Confederates, on December 11, 1862, had effectually stopped the building of the bridges across the Rappahannock, part of the Seventh Michigan and Eighty-Ninth New York were thrown across the river in pontons at two different places and without difficulty drove out the Confederate sharpshooters and captured a large proportion of them. In these instances, the pontons each carried twenty to twenty-five men, exclusive of the oarsmen.

At Chancellorsville, the tactics successfully employed at Fredericksburg were repeated. This time we find the pontons carrying landing parties as large as forty-five men. The trip across the river was short, some 400-450 feet, and the water was not deep. There was, therefore, not much danger from drowning. If the men remained quiet in the boat for the few seconds needed to pass the deeper part of the stream they were safe. Although such

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*Alexander, R. R., S. N. 12, p. 137.
Franklin, R. R., S. N. 12, p. 615.
Arnold, R. R., S. N. 12, p. 618.
†Woodbury, R. R., S. N. 81, p. 170.
Spaulding, R. R., S. N. 81, p. 176.

loading does not tax the buoyancy of the craft, it nevertheless greatly cramps the oarsmen. This instance is the highest ferrying rate of the pontons recorded during the Civil War.

At Chattanooga, in Smith's expedition to Moccasin Point, 1,600 men, inclusive of the oarsmen, and at the rate of twenty-five to a ponton, exclusive of crew, were ferried safely a distance of 9 miles. After landing these men, the boats at once ferried the remainder of the 5,000 men and the artillery batteries across the Tennessee, some 1,300 feet wide.

Smith's later ferrying of Sherman's Corps across the Tennessee to Missionary Ridge, much resembled the operation at Moccasin Point. The numbers carried were considerably greater.

On the 20th of June at Deep Bottom we see an expedition of 1,400 men of the Army of the James ferried safely across the James from Jones Landing, to cover the construction of the ponton bridge at Jones Neck.*

After the incident at Fredericksburg, there were practically no further attempts to construct bridges in the face of an active hostile force. In every instance, men were first ferried across the stream with a view to driving off the enemy or seizing a position from which the bridge construction could be covered by friendly fire. The Rebellion Records afford many illustrations of these tactics. Both canvas and wooden pontons were used in such cases.†

The wooden boat is much stiffer in the nautical sense than the metal boats which have thus far been made, and it performs better as an individual craft in the water. The sudden shifting of a human cargo in a crowded boat meets with a violent reaction if the boat be of metal, whilst the inertia of a wooden boat causes it to respond more gradually to changes in the forces acting upon the boat—either internal, due to changes of the center of gravity, or external, due to wind or wave action.

The fact that a wooden craft is unsinkable inspires the crew and passengers with a confidence that is lacking with the metal boat. Compartments that are supposed to be air-tight in an iron boat do not inspire confidence because the fair inference is that habitually, in campaign, they are not air-tight.

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*Lubey, R. R., S. N. 81, p. 435.

Benham, R. R., S. N. 81, p. 213.

†Battle of Chancellorsville.

J. H. Wilson's passage of the Chickahominy at Long Bridge, night of 12-13, June, 1864.

Van Brocklin's passage of Mattapony at Dunkirk, R. R., S. N. 81, p. 314.

Sheridan's passage of the Pamunkey, May 27, 1864; R. R., S. N. 67, pp. 312, 804.

Wood's passage of Duck River in the pursuit after Battle of Nashville, R. R., S. N. 93, p. 136.

If the French ponton used in our Civil War had been built of metal, it is greatly to be doubted that it would have been used as a ferry in the bold manner that is recorded.

It is also worthy of note that a sectional ponton, with its bulkheads, will not lend itself well as a ferry to the carrying of large numbers of men.

MOBILITY.

No part of the development of bridge equipage in our Army is more interesting than that concerning its mobility. Nor was any other part of its development so slow. It is apparent that at the outset, the designers of the equipage, as well as the commanders in the field, had an inadequate conception of the functions of the equipage. The eastern armies received the bulk of the care and attention of the Government at first, and the eastern armies were operating in a region thoroughly intersected by tidal and other streams. Water traffic played a big part in the early operations. The forces were supplied by boats, through base depots on waterways; the navy guns played a tactical part in many of the battles; and, finally, the bridge equipage was transported from place to place chiefly by water. The water habit, therefore, seems to have become fixed. Before the Peninsula Campaign, the Rebellion Records and the memoirs show no distinct desire on anybody's part to make the equipage mobile by land. Wagons indeed were provided, but apparently as an auxiliary. Boats were to be transported by land only when, in the absence of water facilities, movement was imperative. For such movement by land, animals were to be obtained fortuitously from the Quartermaster Department.

Between 150 and 200 boats were taken to the Peninsula in March, 1862, and when the movement past Williamsburg was made in the advance upon Richmond, but one train was taken along by land. Franklin carried by water some seventy pontons to West Point. The animals, which hauled this single train up the Peninsula, were not part of the train, but seemed to be the usual Quartermaster loan and they shortly found their way back whence they came. Borrowed teamsters are actually of less value than borrowed animals; their heart is not in the work and their discipline is poor.

Spaulding says:*

> The advance guard train (canvas) and the French (wooden) ponton trains taken to the Peninsula in 1862 were, as you are doubtless aware, very deficient in transportation, depending for movement from place to place upon temporary loans of teams from the quartermaster department and the consequence was that during the Seven Days' Battles, nine-tenths† of all the bridge material with the army at the commencement of these battles was necessarily either destroyed or abandoned to the enemy.
>
> The same evil, but to a less extent, prevailed in the organization of the bridge trains operating on the Rappahannock in 1863, and, though I made repeated protests against this system, the evil was but partially remedied. The trains sent into the field, both wagons and bridge material, were in many cases unfit for service, and often required nearly as much work in the field as had been done in the shops to fit them for efficient service. It was not until the spring of 1864 that the bridge trains of the Army of the Potomac were properly fitted up for active field operations.
>
> By the addition of the light canvas trains, as designed by Major Duane, and by his assistance and cordial cooperation with me in my efforts to fit up and organize these trains, they were at last organized in a manner to render the most efficient service. When these trains crossed the Rapidan in the spring of 1864, it is believed that they were more perfectly arranged than any bridge trains before organized in America; and for the truth of this statement and for the efficiency of the troops having them in charge, no better evidence can be given than a statement of the facts that from the crossing of the Rapidan in the spring of 1864 to the close of the war, no bridge material was ever lost, destroyed, or abandoned to the enemy, nor, so far as I am aware, were any troops ever kept waiting for the construction of these bridges. ‡

The same lack of animal transportation is observed in the Antietam Campaign, where the train was carried to Harpers Ferry via the Chesapeake and Ohio Canal.

The details of the Fredericksburg Campaign have been threshed out already. Suffice it to point out at this time that the absence of animal transportation for the train was the seed of Burnside's first crop of troubles. If Woodbury had been a man of Colonel Spaulding's energy, the pontons would have reached Fredericksburg in due time in any case, but on the other hand the lack of animal transportation was the cause that permitted Woodbury to be absent from the side of the supreme commander in the field.

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*R. R., S. N. 95, p. 649.

†More than half of the material, however, had been placed in depot at Fort Monroe. See also Barnard, R. R., S. N. 12, p. 121, and Woodbury, R. R., S. N. 12, p. 149.

‡There was a slight delay of the trains at Coles Ferry, June 14, 1862, and some delay at the Powhatan bridge on the James the same day.

At Chancellorsville, animals seem to have been more plentiful, but they were still borrowed teams and note the conduct of the teamsters in throwing the train in disorder* when fired upon April 29th, thereby delaying the arrival of the boats and upsetting the arrangements already made with General Wadsworth's force, which was to be ferried across the Rappahannock. The conduct of the hireling in this case was traditional. The teamsters, as well as the animals, should be part and parcel of the Engineer train.

In the Gettysburg Campaign there seems to have been no thought on the part of the authorities even yet to provide land transportation for the trains. These were again transported from Fredericksburg by water to Edwards Ferry on the Potomac, and thereafter the equipage was returned by water (Chesapeake and Ohio Canal) to depot in Washington.

In the winter of 1863-1864 at Brandy Station the change commenced, as has been seen in the words of Colonel Spaulding above. Thereafter the Army of the Potomac was never without at least 1,500 feet of equipage, completely equipped with the most mobile land transportation.

Turning to the western armies, it is probable that the check experienced by Rosecrans in his passage of the Tennessee River at Bridgeport, Ala., in September, 1862, bore rich fruit, for although the subsequent operations around Chattanooga did not result in completely mobilizing the equipage in the fall of 1863, nevertheless, the spring campaign opened with about 1,400 feet of equipage well equipped with transportation. As Sherman's army proceeded via Atlanta and Savannah to Raleigh, the amount of equipage was continually increased and its mobility and serviceability constantly improved.

In the spring of 1865 we find this order:†

(Circular) Headquarters, 14th Army Corps,
Crossing of Catawba River, *Feb. 28, '65.*

The delay at this point renders necessary the utmost energy to retrieve lost time. Every means must be taken to prepare the command for rapid and forced marching. All carriages, buggies,

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*Benham, R. R., S. N. 39, p. 209.
Bragg, R. R., S. N. 39, p. 272.

†R. R., S. N. 99, p. 613.

forage wagons, ox teams, and other unauthorized vehicles must be immediately destroyed. Any mules required by circular of February 19 to be turned over to Colonel Moore, commanding pontoniers, and not yet turned over, will be at once sent to him even if it requires the abandonment of transportation, and if any additional mules can be sent to him from any command, it will be highly appreciated by the corps commander. The mobility and the efficiency of the ponton train is of vital importance to the movements of the army.

By order of Major Gen. J. C. Davis:

A. A. McClurg,
Lt. Col., Chief of Staff.

Another order at the same time is as follows:*

Special Orders
No. 25.
Hdqrs. Left Wing, Army of Georgia,
Near Peques Crossing,
Great Pedee River, S. C., *Mar. 5, 1865.*

* * * * * * *

III. Corps commanders will select from the pack animals of their commands 50 of their best mules, and turn them over to-day to Lt. Col. J. Moore, commanding ponton train. Col. Moore will give in exchange animals now in his train.

By command of Maj. Gen. H. W. Slocum:

Robt. P. Dechert,
Actg. Asst. Adj. Gen.

The lesson of this is plain. It took four years of war to arrive at General Davis' conclusion that the mobility and efficiency of the bridge train is of vital importance to an army. The lesson dearly acquired should not be lost to us.

The cavalry raids of Sheridan and Jas. H. Wilson show an increasing dependence on the canvas train. On Sheridan's first Richmond raid, May 9-24, 1864, he took no bridge train. Twice on the raid he found a pressing need for one; first, on his crossing the Chickahominy under fire at Meadow Bridge,† May 11th, and later, on his return trip when he crossed the Pamunkey at White House.‡ He had already sent to Fort Monroe for a ponton train with which to cross the Pamunkey when it was discovered that the railroad bridge at White House was but partially burned. Sheridan sent two of Merritt's Brigades to collect lumber in the neighborhood. Each man brought in a board or a plank, and enough lumber was thus collected to repair and floor the bridge sufficiently to cross the command.

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*R. R., S. N. 99, p. 691.

†Merritt, R. R., S. N. 67, p. 813.
Sheridan Memoirs, Vol. I, p. 382.
Custer, R. R., S. N. 67, p. 819.

‡Merritt, R. R., S. N. 67, p. 814.
Sheridan Memoirs, Vol. I, p. 389.

On his next raid, June 6-27, to Trevilian Station,* Sheridan carried a train of eight canvas boats under Captain Folwell, Fiftieth New York Engineers. This was Colonel Spaulding's No. 4 train, previously referred to.

In the operations of Sheridan's cavalry with the Second Corps north of the James in July, 1864, he had a train of eighteen canvas boats. He requested† that the same officer, Captain Folwell, who accompanied him with the bridge train on the Trevilian raid, should once again have charge of the train.

In the expedition from Winchester to the southward, February 27-March 26, 1865, Sheridan was ordered‡ to destroy the Virginia Central R. R., the James River Canal, capture Lynchburg if practicable, and then to join General Sherman. He reduced his wheeled transportation to a minimum, but carried a train of eight boats. The column crossed the North§ Fork of the Shenandoah on the pontons and proceeded via New Market, Harrisonburg, and Staunton. Sheridan aimed to cross the James River on a covered bridge at Duguidsville. The bridge was fired by the enemy, however, as was also the one across the James at Hardwicksville. The eight pontons were insufficient‖ to bridge the James. Sheridan therefore being unable to cross the river, abandoned the plan to join Sherman or to move back into the Shenandoah Valley. He set out for White House to join Grant's army at Petersburg, sending ahead messages to meet him at White House with pontons and supplies.

Considering that several large rivers lay across the path leading to Sherman and that the spring rains might be expected to swell the rivers, it would be interesting to know Sheridan's reasons for not taking along a train of more than eight boats.

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*Spaulding, R. R., S. N. 67, p. 315.
Sheridan Memoirs, Vol. I, pp. 414, 417, 427.

†Spaulding, R. R., S. N. 80, p. 299.

‡Sheridan, R. R., S. N. 95, p. 475.
Grant, R. R., S. N. 95, p. 48.

§Sheridan, R. R., S. N. 95, p. 475.
Devin, R. R., S. N. 95, p. 489.

‖Sheridan, R. R., S. N. 95, p. 478.
Devin, R. R., S. N. 95, p. 491.
Sheridan Memoirs, Vol. I, p. 119.

In Jas. H. Wilson's early career he showed much cleverness in compensating for the lack of ponton equipage. At Vicksburg he saw a large army with but a single small train. Later, at Chattanooga, he witnessed the intense activity of Gen. Wm. F. Smith in manufacture and use of pontons. Subsequent to the Missionary Ridge fight, while Wilson as Grant's inspector general was en route from Knoxville to Chattanooga, he superintended the construction of two extemporized trestle bridges, the first on November 30th at Charleston,* Tenn., to put Howard's Eleventh Corps north of the Hiwassee River and again on December 3d to put the Fifteenth (Sherman's) Corps north of the Little Tennessee,† both en route to relieve the besieged Burnside at Knoxville. Neither corps had taken any bridge train with it on leaving Chattanooga. The lack of a train cost these corps two days of delay at the rivers mentioned.

In the spring of 1864, Wilson commanded a Division of Sheridan's Cavalry Corps and took part in the first raid around Lee's army May 9-24. The incidents at Meadow Bridge on the Chickahominy and at the Railway Bridge on the Pamunkey were not taken to heart at once by the self-reliant Wilson, for we see him start out for Petersburg, June 22d, with his own and Kautz's divisions, totaling 5,500 cavalry and two batteries, to make a bold dash into the heart of the enemy's country without so much as a ponton. His instructions were to cut the two railroads then supplying Petersburg from the south. His objective was Burkeville, an intersection of these railroads. He succeeded signally in the object till, on the return trip, he was cut off and severely damaged by the Confederates at Reams Station.

He then made a detour from the Confederate front, so as to cross Blackwater Creek at Blunts Bridge, 22 miles southeast of Petersburg. He reached the spot in the dead of night, only to find the bridge destroyed and the stream wide and deep. He at once set about to repair the burned bridge. The site was a dismal swamp, distant from any habitation. By some make-shift of his own, Wilson managed to get his command across the river

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*Wilson, R. R., S. N. 54, p. 431.
———, R. R., S. N. 54, p. 432.
Howard, R. R., S. N. 56, p. 282.

†Sherman, R. R., S. N. 56, p. 317.
Howard, R. R., S. N. 56, p. 318.
Wilson, R. R., S. N. 56, p. 316.

and to safety by daybreak, just as the Confederates reached the stream.* His escape was providential. Wilson next moved with his division, in August, 1864, to the Shenandoah Valley, under Sheridan, and from there in October, 1864, he set out for the south to command Sherman's Cavalry. His part in the Franklin-Nashville Campaign has already been described. At Duck River Wilson finally encountered a stream that ingenuity alone could not bridge. He must have realized keenly the penalty exacted of the Union cause that day because of the lack of a ponton train, equipped and handled in a manner commensurate with the mobility displayed by the other elements of Thomas' army in the superb pursuit of Hood.

In his spring campaign of March 22-April 22, 1865, in which Wilson's independent command of 14,000 cavalry moved from Chickasaw to Selma, Ala., and to Macon, Ga., he carried a model bridge train. The train† consisted of fifty-eight wagons with thirty canvas pontons. The pontoniers were the Third Battalion Twelfth Missouri Cavalry, five officers and 205 men, commanded by Maj. J. M. Hubbard. The train marched from Eastport, Miss., to Selma, Ala., 227 miles in seventeen days, averaging thus over 13 miles per day, including the bridging of four rivers. Wilson's several columns, nevertheless, in the march from the Tennessee River to Selma, did not usually wait on the ponton or supply trains, but shoved ahead, fording or swimming the rivers. At Selma, Wilson realized the Alabama River was too wide for his equipage and he immediately caused his staff engineer officer to use the shops of Selma to build additional wooden boats.‡ Hubbard, arriving with the portable train, then bridged the Alabama, using thirty canvas, sixteen of the newly built wooden boats and three barges; total length of bridge, about 800 feet. The command then proceeded to Macon, Ga. Hubbard, under orders, destroyed, before leaving Selma, all his equipage except enough for twelve bays of canvas equipage. It was known that no other great river would be encountered and Wilson desired to lighten the column.* The animals liberated by the destruction of wagons were used to mount the pontoniers. The train marched from Selma to Macon, 240 miles, including the bridging of one river, in twelve days; average rate per day, 20 miles. It is worthy of note that Hubbard's entire train—pontoniers, teamsters, animals, as well as material, was wholly under his command.

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*"Under the Old Flag," Vol. I, p. 474.
Wilson, R. R., S. N. 80, p. 630.
Chapman, R. R., S. N. 80, p. 647.

†Hubbard, R. R., S. N. 103, p. 411.
Wilson, R. R., S. N. 103, p. 356.

‡Wilson, R. R., S. N. 103, p. 361.
Hubbard, R. R., S. N. 103, p. 412.
Hubbard's two reports in this Volume of the Records display several inaccuracies in figures. The average marches as given by him are altered above to accord more closely with measured distances.

We have now seen at the close of a long war, waged over a vast range of territory, under a great variety of conditions as to climate, geography, and personnel, that all the separate armies—Grant's in Virginia, Sherman's in the southeast, and Thomas' in Tennessee and Mississippi, concurred in having their bridge trains thoroughly equipped with wagon and animal transportation. That these animals were not the culls of the corral, but were the best available; and that they did not come as a fortuitous loan but were an integral part of the ponton train. This unanimity of type having been reached in the school of war by independent ideas over a variety of routes, by a varied personnel, is entitled to the greatest weight with us to-day. It is fitting that one of the best exhibitions of the mobility of a mounted bridge train during the war should have been made by General Wilson's command.

The Ponton Manual says (page 15):

> The canvas equipage, also, was perfectly successful as an advance guard train. In the cavalry raids it was always able to keep pace with the columns; and, although they frequently marched hundreds of miles, it was invariably ready to furnish a prompt and secure means of crossing all the streams on their route. It also often furnished bridges for the heavy trains of the army over streams of moderate width and rapidity.

THE FUTURE OF THE EQUIPAGE.

In the operations of the Civil War, the equipage is shown to have accomplished to an eminent degree the purpose for which it was designed.

The three fundamental conditions imposed by the designers, viz: capacity, ferriage, and mobility were fulfilled in the design of the equipage and its success followed logically. In a study of the performance of the equipage during the first years after its adoption during the great test of the Civil War, the principle purpose is to determine what lessons may be drawn that will tend to the improvement or the development of the equipage, for its present and future uses. Though the equipage served its purpose well in the past, it might indeed be inadequate for present needs. It has been stated in this connection that any military apparatus whose design is more than fifty years old must needs, in this day, be antiquated.

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*Wilson, R. R., S. N. 103, p. 362.

Hubbard, R. R., S. N. 103, p. 412.

A comparison of the European equipages shows that most of the leading powers have adopted the metal ponton, leaving the United States, England, Switzerland, and Italy alone in the use of the wooden boat.*

A comparative study of the equipages of the leading powers is beyond the scope of this paper. Such a study in detail has lately been completed by Maj. W. G. Caples, Corps of Engineers.

The use of metal boats in military equipages is by no means new. Major Flagler, Corps of Engineers, in a study† of the development and tactics of bridge equipages, shows that metal boats were used in Europe as far back as the Seventeenth Century, and that during the Eighteenth Century, because of their many shortcomings, they fell into disfavor with many nations. The metals used have been iron, copper and tin, and steel. The metal boat therefore is by no means a certain index of novelty or of progress in equipages. Within the last fifteen years, metal boats have been once again tried out to some extent in the American Service. The tests were inspired by two causes: first, the general adoption of the metal boat abroad; second, the practical disappearance from American lumber yards of the fine specimens of white pine formerly so cheap and so abundant. The tests have included steel boats in 1, 2, and 3 piece units. The shapes and sizes have generally been similar to those of the Service ponton. The tests resulted in some of the same objections noted by the Board of Engineer Officers in 1859, viz, that for acceptable strengths, the metal boats are quite as heavy as the wooden, usually a trifle heavier. They are very noisy on the march, a considerable defect where secrecy is sought. They do not withstand the shocks of wagon transportation on our bad roads as well as do the wooden boats. Rust inevitably eats away much of the thickness of steel plate, necessitating a considerable increase of section and therefore of weight over that needed for new plate. No amount of painting will wholly prevent rusting in the conditions of the Service, though an expensive non-corrosive metal might be used. It is in practice impossible to maintain the boats non-sinkable, even by the use of air-tight compartments. As an individual craft, the metal boat is not so handy as the wooden. In marine parlance, it is cranky as opposed to the stiffness of the wooden boat. American troops in their limited experimenting with metal boats, have shown a decided distrust of the sinkable boat. Their customary boldness of maneuver with the wooden ponton is not manifest when using metal boats in dangerous waters.

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*France, since its adoption of the metal ponton, continues to use its former wooden boats.

†Professional Memoirs, Corps of Engineers; Vol. IV, p. 373.

Every officer who has had experience with bridge equipage can recollect occasions when a boat in or out of the bridge has filled with water and been submerged. With a non-sinkable boat, no great harm usually ensues even when the boat is in the bridge. With a sinkable boat, however, such an accident may not only endanger life, but delay or even frustrate the plans of the commander.

The Civil War has shown many instances when it was necessary to repair or to build pontons in the field or to procure suddenly large amounts of equipage.* The steel pontons have the advantage that they could be turned out quickly in great numbers by the large steel manufactories of the country; it is doubtful, however, if they can be manufactured much more quickly than the wooden ones. Experiments have shown that with a portable oxy-acetylene flame, repairs to the metal boats are simple. On the whole, however, it can not be doubted that both in respect to construction and repairs in the field, the advantage rests decidedly with the wooden boat.

The difficulty in obtaining suitable lumber now-a-days concerns really the balks of the floor system more than it does the boats or the floor chess. A few knots or checks in the boat planking or chess may be obviated, but they are most unwelcome in the balks. In a separate paper,† the authors have investigated the practicability of steel for use as balks. A 3-inch I-beam would obviously be too small. A 4-inch I-beam, though strong for 15½-foot spans weighs 1½ that of the wooden 5-inch balk, and to utilize the excess strength, it would be necessary to decrease the total number of balk in a span. Three balk is the least number that could properly be used. The weight of three 4-inch I-beams is nearly equal to that of five wooden balk, but the intervals between the I's being now increased, the thickness of the floor chess must be correspondingly increased. Thus the total weight of the equipage by the use of three 4-inch I-beams as balks will be increased. Moreover, 4-inch I-beams 27½ feet long are too heavy for two men to lift in the field, and it is practically certain that they could not withstand without distortion the shocks of transportation in campaign. The weight of 5-inch I-beam balks would be prohibitive for two men, and the beams probably could not withstand the shocks of handling in campaign. A box girder of 4-inch channels connected by ¼-inch plates, though very strong, is too heavy to be considered.

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*Berlin, on Potomac River; Chattanooga; Knoxville; Selma; New Orleans.

†Bridge Equipage of U. S. Army.—In what respects is Necessity for Improvement Indicated and how may such Improvement be Accomplished? Engineer School, Fort Leavenworth, 1913.

Though it is impossible to-day to obtain in the open market from a lumber yard the long lengths of clear white pine needed for balk, it is believed to be practicable to procure them if a large order with a considerable time limit for delivery be placed. The price will, of course, be somewhat high. White pine is far from being extinct yet. There are many forest reserves, State and Federal, which still contain excellent white pine. There are also several substitutes for the white pine which, though all inferior to it in general adaptability to the service, are nevertheless adequate to the purpose. Among these are Canadian white pine* and upland spruce of our northwest.† These substitutes could be utilized until a sufficient supply of white pine be obtained. The paucity of white pine supply has certainly not been established to the extent of justifying its rejection from the equipage; and its suitability for the equipage is such that the most vigorous efforts should be directed to maintaining its supply.

The question now arises, What change has the passage of the years imposed upon the rôle of the bridge equipage? Is it now expected to do more work, or work of nature different from that of fifty years ago? The function of a military floating bridge, in the language of General Barnard, is to carry an army and to be carried with an army. Wagon loads in campaign are functions of road surface and tractive power. The road surfaces in the Civil War were generally about the worst that could be classified as highways; the rains and the passage of large bodies of foot, horse, and vehicles, reduced these roads in innumerable instances to a desperate condition. To-day we see in all parts of the nation an awakening to the value of good roads, the change being due chiefly to the influence of the motor car. Already a considerable start has been made in a fairly comprehensive scheme of highway improvement. It will, however, be a very long time before the roads of the probable theaters of American operations will be improved to the extent that mechanical traction can be depended on in campaign. Until that time arrives, the Army will continue to use the mule. Since the roads during campaign, and the mule are essentially the same as heretofore, there is no material change in wagon loads. The weight and the distribution of the load behind a six or eight-line team to-day are not materially different from what they were fifty years ago. The three conditions of capacity, ferriage, and mobility imposed by the Board of Officers in 1859, are as applicable now as then. It is clear then that the developments of the last fifty years have not materially altered the rôle of the bridge equipage.

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*Used in the equipage at Fort Leavenworth.

†Earle, Professional Memoirs, Corps of Engineers; Vol. III, p. 456.

The experiences of the Civil War show the need for two types of bridge, the light mobile type and the more hardy type. On this subject the Ponton Manual says:*

> The canvas train was extensively used by the Western army, and with such success that it was proposed to employ it exclusively. Experience, however, in the east has clearly proved that this train cannot fulfil all that is required of the bridge equipage of a large army. The bridges of the Potomac and the James rivers could not have been built with canvas boats, which will not resist ice and driftwood; neither are they suited to the disembarkation of troops or the passage of a river by force.

CONCLUSION.

1. Our own experience subsequent to the Civil War, as well as the current practice of many foreign nations, demonstrates that the reasons calling for two types of bridge, the light and the heavy, are as weighty to-day as they were at the time of the Civil War.

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*Ponton Manual, p. 16.

2. The pontons must be strong, light, and individually manageable craft.

3. Notwithstanding the very general use of metal boats in the foreign equipages, the Civil War and our own experiments have thus far failed to establish the superiority of the metal boat under American conditions.

4. As to the floor system, nothing superior to the white pine has been proposed or discovered. This being admitted, the most vigorous efforts should be directed to the continuance of the supply of white pine, even at a considerable increase of cost. It should not be admitted that white pine can no longer be obtained in suitable dimensions and quantity until the most positive proof thereof has been obtained.

5. In campaign, complete animal transportation with teamsters should be permanently assigned to the bridge trains.

6. In a single field army operating within the same theater, and using several ponton trains, the best results flow from having the movements of all trains controlled in a general way by a single individual.

7. Our present equipage has satisfactorily withstood a test such as no other, to the writer's knowledge, has been subjected. The conditions of service for the bridge train to-day do not differ greatly from those which obtained in the Civil War. It is a remarkable tribute to the wisdom of those who designed the present equipage that, in fifty years of time and continuous study officers of the Corps of Engineers have not developed a single radical improvement in the equipage.

[The word ''pontoon,'' wherever it occurs in quoted matter in this article, has been changed to ''ponton'' to conform to modern practice.—ED.]

Reconnoissance Equipment

BY

Maj. W. G. CAPLES
Corps of Engineers

There was so much difference of opinion in the Army as to the equipment necessary for field sketching that the Chief of Staff ordered the Chief of Engineers to design a standard equipment based upon the sole use of the plane-table method and to make recommendations as to the assignment of this equipment to arms other than the engineers. The Chief of Engineers assigned the details of this work to the Board on Engineer Troops, with the added instructions that a suitable container should be designed for the outfit. The design and plan of assignment have received the approval of the Secretary of War, and the first lot of these outfits is now being assembled at the Engineer Depot at Washington Barracks. Until the large supply of instruments on hand is worn out, these outfits will be issued only to engineer troops and service schools while a war supply is accumulated at the depots.

The instructions of the Chief of Staff to provide only for the plane-table method of sketching greatly simplified the task of design. As the outfit is for issue to all arms, it must necessarily provide for both foot and mounted sketching. Following the methods and equipment most commonly used, it was decided that the equipment necessary would be as follows:

Mounted.

1 Alidade.
1 Board, sketching.
Celluloid, sheets.
1 Clinometer, service, with case.
Erasers, rubber.
1 Holder, timing pad.
*1 Knife.
Pads, timing.
Paper, sketching board, sheets.
Pencils, colored.
Pencils, drawing.
1 Pencil Pocket.
Protectors, pencil point.
*1 Watch.

Foot.

1 Alidade.
1 Board, sketching.
Celluloid, sheets.
1 Clinometer, service, with case.
Erasers, rubber.
*1 Knife.
1 Pace Tally.
Paper, sketching board, sheets.
Pencils, colored.
Pencils, drawing.
1 Pencil Pocket.
Protectors, pencil point.
1 Tripod, wood, folding.
*1 Watch.

The articles marked * form part of an officer's personal equipment and were therefore omitted from further consideration. The opinions of numerous officers were obtained and all records of complaint in regard to items of reconnoissance equipment were collected with a view to making the new equipment free from defects which had appeared in the old.

The complaints against the veneered boards, Model of 1912, were:

(a) The boards warped;
(b) The needle was not sufficiently sensitive;
(c) The needle-release screw was too easily broken off;
(d) The paper clips would not hold the paper in a high wind;
(e) The lead plumb-bob was unnecessary;
(f) The squares on the face of the board and the protractor scale on the edges were useless and interfered with locating points of intersection when the latter fell on the ruled lines;
(g) The board could not be held firmly to a tripod;
(h) Repair parts were hard to get and repairs hard to make.

All of these objections have been met in the new board. The board is of 5/8-inch white pine, with end pieces to prevent warping, and has screws over slotted washers in the ends to permit of expansion. In fact, it is built like the highest grade drawing boards. The new needle is a 3-inch transit needle, mounted with a hard agate or white sapphire center well polished out. It will be found more sensitive than the needles on many transits with which good surveys are made every day. The needle pivot is the point of a No. O sewing needle and can be renewed in a few minutes. The needle-release screw has been replaced by a thumb lever and cam, which are much stronger and simpler than the screw and have given excellent service with the Geological Survey. The glass on the needle trough is 3-16-inch plate, strong enough to withstand a blow that will tear the trough off the board. The paper clips have been given a concave under-surface, the head increased to 3/4-inch diameter, and the stems set eccentric to allow a grip of 1/2 inch on the paper. A single clip will hold a sheet of paper against a straight pull which will tear the paper in two. The plumb-bob and unnecessary markings have been omitted. However, a hole is accurately bored so that a plumb-bob can be improvised and use made of the slope-scale on the board in case the clinometer should be lost. The plate on the back of the board is let in flush so that the board can be turned freely on the tripod for orientation and then firmly clamped by a slight turn of the tripod screw. The grip of this screw is enough to prevent the board from turning on the tripod from an accidental touch by the sketcher's body, but not so strong but that a man can take both hands and deliberately twist the board around even when screwed as tightly as the screw will hold. As tripods are not needed for mounted sketching, holes have been bored at the corners of the board for the insertion of a carrying cord if desired. The boards are built on the duplicate-part system and any required repair can be made with a screwdriver and pocket knife.

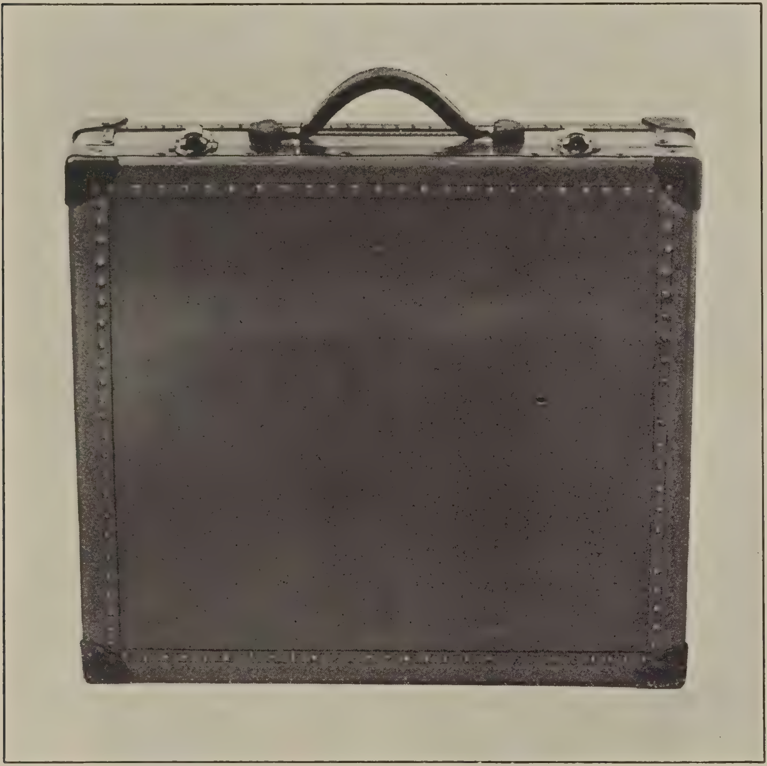

Fig. 1. Field Sketching Outfit in Container.

A slight improvement has been made in the alidade. It is now $10\frac{3}{16}$ inches long. All slope scales will be found on one face. The blanks for pasting on individual scales of paces, walk, trot and gallop, are all on another face.

The complaints against the service clinometer were that:

(a) The pendulum came violently against the stops, racking the instrument and quickly throwing it out of adjustment;

(b) The brass pivots soon wore, could not be renewed, and gave a permanent index error;

(c) The brass bearings wore, giving the scale ring an eccentric motion.

In the new model, springs have been placed on the arm of the pendulum. These springs strike the stops and take up all shock. The pivots are made of hardened steel wire and can be renewed. The bearings are of case-hardened steel, harder than the pivots, and put all the wear on the latter. The instrument is built on the duplicate-part system. All repairs and adjustments can be made with a knife, a screw-driver, and a bit of wire.

The timing pad holder is an adaptation from the home-made ones used at the Army Service Schools. Upon advices received from these schools, the place for the watch has been omitted. The new holder consists of a board with spring clips for the pad, a wrist strap, and pencil-holder; the last two items being specially woven by the Mills Woven Cartridge Belt Company. The pads themselves are filled with one hundred sheets, exactly like those used at the Army Service Schools. A linen cover is provided with each pad.

The pace tally is of a form of which numerous models, representing different stages of development have been issued. The first models were actuated by a spring which became bent and might then cause the instruments to register backward. In later models, this spring was replaced by a piece of sheet brass actuated by a flat spring. These springs proved too weak and, in the latest model, have been replaced by a spring loop which appears satisfactory. The latest model has been issued for the past three years and not one has come in for repairs. However, it is required that the springs and exposed parts of the mechanism shall be made on the duplicate-part system. The train of gears is not worth repairing once it has worn out, but no worn-out trains have been found even in the instruments longest issued.

The tripod was a knotty problem. Everywhere complaints were received that the tripods issued were too unstable. Many officers insisted upon a transit tripod, apparently not considering that the weight of such a support made it out of the question. There was a very general insistence that the tripod should be at least as rigid as the tripod carried by the Geological Survey with their traverse tables. This tripod has solid legs and weighs 7 pounds. The first experimental work was done with folding metal tripods. All were found unsatisfactory. The Eastman Kodak Company submitted a special design representing the highest development of the metal tripod, but it lacked the necessary strength and rigidity, while repairs in the field would have been about out of the question. A trial of wooden tripods was then made. Tests of various ones indicated that for quality of materials, workmanship, and design, light weight and rigidity combined, and ease of repair, the ''Crown'' tripod, manufactured by the Folmer and Schwing Division of the Eastman Kodak Company, is superior to any other on the market. This tripod is actually more rigid than the solid-leg tripods, furnished for transits. The camera tripods were too large for our purpose, the screws too light, and the screw shank too short. A design was then made, based upon the Crown tripod, for a tripod that will fold to 15 inches and extend to 40¾ inches. The screw was made ⅜ inch diameter, with U. S. standard threads, and the shank was extended and provided with a knurled head. A collar was turned on the shank. This collar, when the screw is fully set, presses against a brass plate in the bottom of the tripod head and causes the sketching board to be drawn down to firm contact with the head. A slight turn releases the board enough to permit of orientation. These tripods are now being furnished by the Eastman Kodak Company and are of the highest quality made by them. They can not be used with the old model boards, as the projecting screw plates on the backs of the latter tear the head of the tripod and do not afford sufficient bearing surface to keep the board from turning.

The pencil pocket is an improved model of the home-made ones used at the Army Service Schools. It is woven by the Mills Woven Cartridge Belt Company. A flap and snap catch have been provided for the eraser pocket to eliminate the troublesome loss of erasers in the field. Eyelets are provided for attaching the pocket to the shirt by means of safety pins taken from bandoliers of cartridges and for running a cord between the alidade and the pocket if so desired, although the grip of the woven fabric is sufficient to keep any article from falling out of the pocket.

The majority opinion obtained was that celluloid should be furnished for sketching in the rain, and that both celluloid and paper should be in sheets rather than in rolls. The spacing of paper clips on the board calls for a sheet 13⅛ inches wide. The length of the sheet is limited by the width of the sketching board. A standard size of sheet, 12½ inches by 13⅛ inches was adopted. The celluloid is a very thin transparent grade with one grained surface, such as has been supplied by The Celluloid Company to the Army Service Schools. The paper is "Collona Medium Thin," developed specially for military sketching by Messrs. Keuffel and Esser in accordance with suggestions received from the Engineer Department. This firm, who made also the standard samples of all the instruments, cooperated heartily and succeeded in producing a pad in which the sheets are not wrinkled by the glue used in binding, and each sheet is readily detachable. Each pad contains 72 sheets and is furnished in a fuller-board envelope large enough to take both the pads and the sheets of celluloid. The Celluloid Company declined to cooperate, so, until arrangements can be made to get the celluloid elsewhere, large sheets have to be bought and cut with nearly a third waste.

Opinion favored either the Ruby or the Emerald eraser. As both are made by the same maker at the same price, either will be supplied. The kind adopted is double bevel, twelve to the pound. (Ruby, No. 212; Emerald, No. 112.)

In the matter of colored pencils, three colors were considered sufficient: blue for water, green for forests, and red for contours. The best pencils found were the Polychromos Castell. Of these, the No. 21 light blue, the No. 17 Hookers green No. 2, and either the No. 39 dark vermillion or the No. 38 pale vermillion were considered the most suitable.

The opinions obtained were practically universally in favor of the Koh-I-Noor drawing pencil, but individual preferences varied from a B grade to a 3 H. It is impossible at the engineer depots to meet all the individual preferences as to grades of drawing pencil. The H grade was adopted and will be issued.

The pencil point protectors are made for hexagonal pencils and tipped with the same rubber used in the erasers.

For the combination of sketches, Dennison's adhesive tape has been used and proven satisfactory.

After each item of the outfit had been carefully worked out to meet the majority of the opinions obtained, it was necessary to make a list of the equipment required for both mounted and foot sketching and of the supplies that the average sketcher would re-

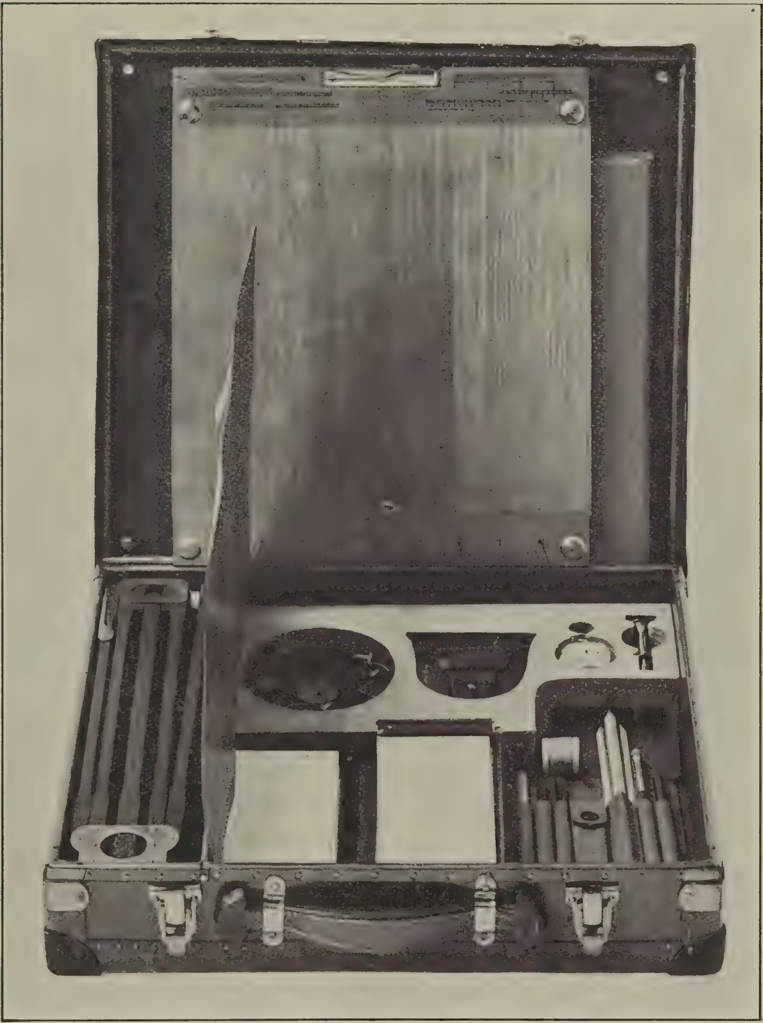

Fig. 2. Field Sketching Outfit. Container open and lid up.

quire in six months of ordinary field service. Some judgment had to be exercised, especially in the amount of supplies, but the latter represents a liberal six months' allowance based upon the average consumption among engineer troops. The outfit is divided into equipment, which is permanent, and supplies, which are expendable. The complete outfit is:

Equipment.

1 Alidade.
1 Board, sketching.
1 Chest, sketching outfit.
1 Clinometer, service, with case.
1 Holder, timing pad.
1 Pace Tally.
1 Pencil Pocket.
1 Tripod, wood, folding.

Supplies. Allowance for Six Months.

12 Celluloid, sheets.
2 Erasers, rubber.
6 Pads, timing.
72 Paper, sketching board, sheets.
2 Pencils, blue.
6 Pencils, drawing, H.
2 Pencils, green.
2 Pencils, red.
2 Protectors, pencil point.
2 Tape, adhesive, rolls.

The approved distribution is one to each regimental and battalion headquarters of cavalry, field artillery, coast artillery acting as infantry, and infantry, and three to each engineer tool wagon, giving six per company or three to a mounted company. Headquarters of higher engineer units and division or chief engineers not attached to engineer units receive normally three such outfits, but division and chief engineers may receive a larger number if they so requisition.

Except for the outfits issued engineer organizations, for whom tool wagons are now building, all will have to be carried in escort wagons along with other articles and will suffer accordingly. The container, therefore, must be as strong as possible. The adopted container is made of fiber-covered board, strongly bound, and light, but as substantial as a field chest. The arrangement is very compact. The tripod legs are strapped into a compartment the full width and thickness of the case. To the right of this compartment are separate compartments for all the small instruments and supplies, the more delicate ones being in close-fitting compartments to avoid shock in transportation. A cloth-hinged fiber lid covers these compartments. On this is laid the sketching board and on it the envelope containing the sheets of celluloid and the pad of sketching board paper. The lid of the case holds everything in place. Suit-case snaps are used for fastening. There is no lock, because the loss of keys in the field is so great as to

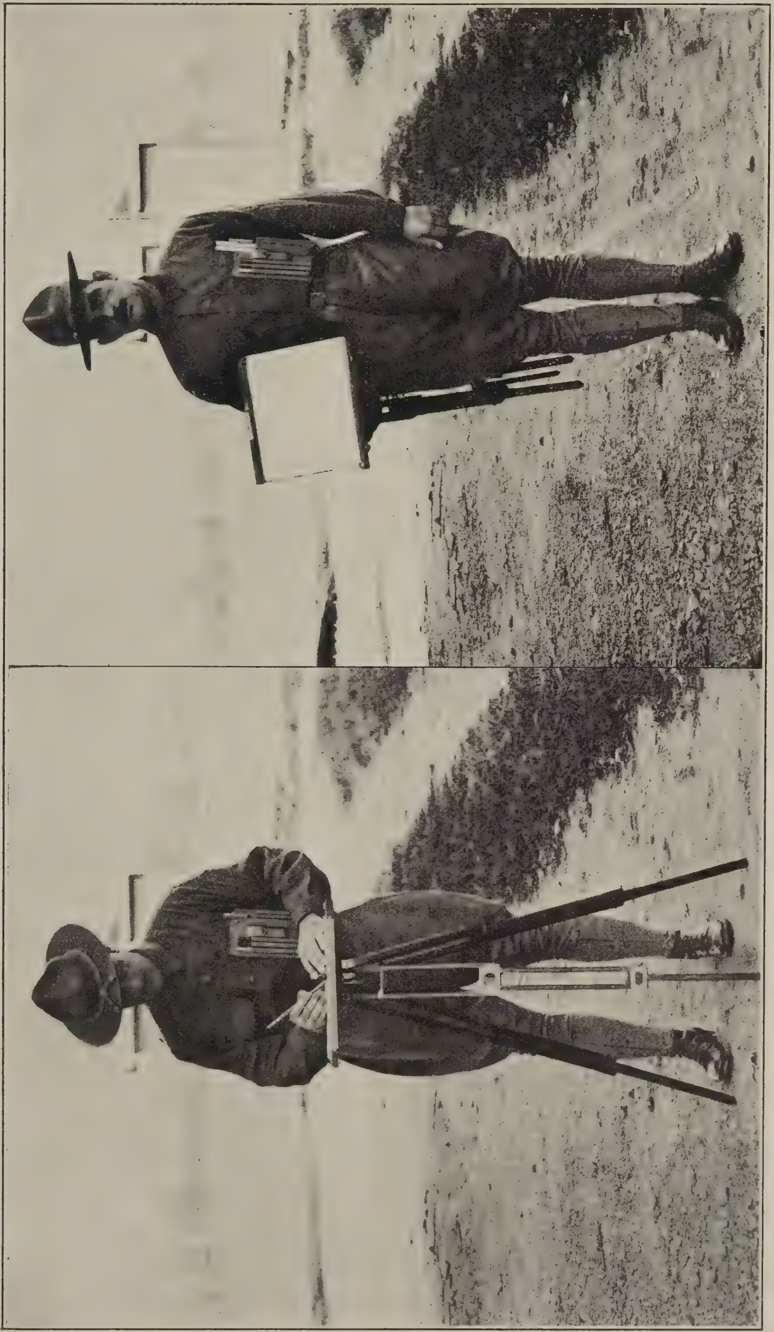

Fig. 3. Sketcher with table set upon tripod for foot sketching.

make locks objectionable. A flat strap handle is provided for carrying.

The Secretary of War has approved the Board's report complete, including the specifications for individual instruments, the design of the container, and the proposed distribution. Coordination between the service schools and the issuing department was had in the design of the outfit. In the future, the use of the new outfit will be exclusively taught at service schools, and the use of instruments not in the equipment will be prohibited to student officers. Under the old plan where each officer was allowed to use what he pleased, different officers got up devices which differed but little from each other but each of which appealed to its designer as the only proper thing for sketching. The result was that the issuing department was besieged with recommendations of one device or another. How numerous these were may be judged from the fact that the Board's letter of instructions from the Chief's office was No. 3216 on the subject of reconnoissance instruments. A really good sketcher can make a creditable sketch with nothing more than a compass and plumb-bob fastened to a piece of plank. Some of the best sketches I have seen were made with such equipment. Yet, most of the devices submitted were complicated and full of small weak parts, and some were even provided with verniers! With officers forced to learn the use of an outfit there will be less snap-judgment improvements (?) to be considered. With a supply of standard outfits purchased, any change adopted must be not merely an improvement but so real and important an improvement that we can not afford to keep our outfits, but must throw them away and buy others at great expense. The probability of any improvement of this kind being made is so slight that it may be said that our reconnoissance equipment for the Army at large has been standardized for many years to come.

While the Army at large is limited exclusively to the use of the plane-table method by the order of the Secretary of War, the Corps of Engineers is not so limited and, in view of the more extended nature of its duties in connection with reconnoissance, did not feel justified in placing such limitation upon its equipment. During the Civil War, our officers were frequently assigned to work where the use of a plane-table was impracticable. For example, an officer sent out with a patrol, which has to frequently vary its gait and can not afford time to halt, would be at a loss to get a sketch with a plane table. During the Russo-Japanese War, the reconnoissance of hostile fortifications was found very important. This work had to be carried out by officers sneaking along and getting information from cover. A plane table would make a man expose himself very quickly. Work of the kinds noted requires the use of a note-book with either the box or prismatic compass and is peculiarly the duty of engineers.

Each engineer company tool wagon will have, in addition to the three field sketching outfits, the following equipment and supplies intended for four sketchers using the plotting method:

Equipment.

Clinometers, service, with cases	4	Pace Tallies	4
Compasses, box	2	Protractors, rectangular	4
Compasses, prismatic	2		

Supplies.

Books, note, field	16	Pencils, green	8
Erasers, rubber, pencil	8	Pencils, red	8
Pencils, blue	8	Protectors, pencil point	8
Pencils, drawing, H	24		

The combined sketching with an army on the march or in position is expected to be done by the engineer officers and troops. For this work the following additional items will be found in each company tool wagon:

Equipment.

Barometers, aneroid, with cases	2	Field Glasses, with cases	1
Odometers, with cases	1		

As road sketching is all to be on horseback, the function of the odometer is merely as a check upon the total distance traveled. It is not intended to measure courses with it, although this can be done if the principal sketcher remains with the tool wagon and has an assistant. The only other item carried is 6 watch compasses. These are intended only for map reading. It is expected that they will be issued to non-commissioned officers other than those who take part in the reconnoissance work proper and thus already have compasses in their possession.

The Tactics of Divisional Engineers*

BY

Lieut. Col. F. E. G. SKEY, R. E.
Commanding Divisional Engineers
6th Division

Many hold the opinion that the number of engineer field companies allotted to a division in our army is comparatively small, and it is certain that in field operations they will require economical handling on sound lines if their full tactical value is to be obtained. One often hears it stated that three instead of two companies to a division would be a more suitable establishment, and as an additional reason for this it is held that each infantry brigade should have a field company, if not as integral portion of itself, at any rate at its disposal whenever it is actively employed. This reason is not a sound one. Though an additional company is highly desirable, any normal distribution of field companies to infantry brigades should be guarded against. It overlooks a very large section of the troops of the division which may require help from the engineers, viz, the artillery, and it further assumes that the requirements of the infantry brigades will be equal and symmetrical, which would probably never occur in practice. The engineers must be divisional troops, and remain in the hands of the divisional commander to allot as he thinks best to meet any emergency that may occur.

When the division is advancing, it is customary to allot one or more sections of engineers to the advanced guard, and of these a portion will join the vanguard and will send forward cyclist scouts as far to the front as possible. The action of an advanced guard on encountering the enemy is well known. It will act with vigor, endeavoring to push aside his covering troops and to gain touch with his main body. When it can get no farther it will dig itself in, with the intention of forming a covering screen behind which the deployment of the main body may be carried on without molestation.

The engineers with the vanguard will be involved in the initial fighting. Their *raison d'être* is not so much an offensive one, as to facilitate the march of the troops; and in the case of a collision

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*Reprinted, by permission, from *The Royal Engineers Journal* (Chatham, England), February, 1914.

with the enemy they should be utilized in clearing the way, and possibly also in the defence of some strong point, some enclosure or group of buildings which may be found on the spot, and which might form a pivot for the attack in case unexpectedly resolute resistance is met with. This action may have to be repeated two or three times before the advanced guard is really held up by superior forces. The end will probably be that the vanguard engineers will be expended, as far as their tactical value is concerned, in the thick of the advanced guard firing line.

The rest of the advanced guard engineers will arrive on the scene near the head of the main guard, and if they are not required to improve communications for the artillery either at first or as the action develops, they should be kept in hand until the time has come for the advanced guard to dig themselves in, when they should be sent forward to the more important point or points of the line. There should be no attempt to distribute them widely along the front, but the commander should endeavor with their help to build up one or more pivots in his line, on which to base his defence during the overwhelming counter-attacks, which he has reason to expect from an enterprising enemy, before the main body can arrive to his assistance. This we may consider to be the end of these sections for the time being. Pinned to the ground and engaged in a desperate defence, they would be no more available until the success of the main body has extricated them, or until the darkness of night enables them to be withdrawn, though, on the other hand, if the advanced guard position becomes part of the firing line of a many days' battle, the darkness of night may mean only an opportunity for improving their defence works. All things considered, it would not be wise to count upon the use of their services again during this particular operation.

Turning now to the action of the main body, we find the rest of the division left with little or no more than a single field company of engineers to carry out all the duties which may be required of these troops during a battle. That these duties are by no means simple or few in number may be gathered from a study of Section 111 of *Engineer Training,* and when it is further laid down that "no considerable portion of the division ordered to carry out a distinct tactical operation should be without its complement of engineers" it will be recognized that their resources, even if they have not already detached a section with the rear guard, will be strained to the uttermost.

Early in the action serious bridging or ferrying problems may have to be tackled, and in this work it is possible that the bridging equipment of the field companies may be called into requisition. If this can be foreseen the pontoons should be brought up in good time to join their companies at the head of the column, for otherwise they will be with the brigade ammunition columns and it will be difficult to get at them quickly.

In detailing engineers to tasks in distant parts of the field, it will be remembered that most of them are dismounted troops and can move no faster than infantry. It should, however, be noted that they have eight cyclists per section, and that a few men can always be carried rapidly on the tool carts in case of necessity.

The need of observatories and crow's nests will probably become prominent at an early stage, in view of the care with which positions are selected to conceal the effect upon them of artillery fire.

Officers preparing for possible future moves of the artillery may require help in cutting openings through natural obstacles, especially when the necessity of the concealment of such moves becomes an all-important item.

The advance of the infantry to the attack will not under the ordinary circumstances of field warfare require any help from the engineers, nor will this be expected. If the country is very close, or even if there are known to be hastily constructed artificial obstacles in their path, there would be nothing easier than to equip a small portion of the infantry with hand axes or cutting pliers. Engineers would be wasted if distributed upon such duties, especially as there is always a far more important service in which their concentrated skill may be of the utmost value, the preparation against counter-attack of some important key which has been gained during the attack. This important service is laid down in *Field Service Regulations* as the work of the local reserves, to which engineer field companies may be attached for their assistance. Here we get a ruling as to the detailing of engineers with other troops in an attack. A special objective is assigned to the operation, special troops are detailed for the attack, and a local reserve is told off with the special object of following the attack and making good against the enemy the defences of the objective when it has been gained. The engineers are attached to this reserve and are placed under the orders of its commander. The attack may follow up its success, knowing that it can count upon the solid backing which will be found, if it is driven back, in the hasty defence work of the local reserve and of its engineer contingent. There is reason to believe that this procedure is not often practised during peace operations. Engineers alone, in such a case, could show but small results, but engineers with infantry *if well trained in utilizing to the utmost their combined efforts,* might in the shortest space of time do work whose effect upon the result of the operation might be little less than decisive. We may assume that there will always be a counter-attack, there will always be an attempt to regain a lost point of vantage if it is of any value, and if this counter-attack is made by fresh troops, more often than not the crucial struggle will take place round the defences hastily organized by the commander of the local reserve with the help of his sappers in the key of the captured locality.

The paragraphs in *Field Service Regulations,* Part I, devoted to night advances and night assaults, bring out prominently and in considerable detail an important application of this action. Here we see the detail of the assaulting columns and of the reserve; here the equipping of the working parties as a result of engineer reconnaissance of the objective; here the provision of hours of darkness to enable them to prepare and organize their defences against a counter-attack at dawn. There is no doubt that all available sappers must be concentrated to work with this reserve, and if any have been employed earlier in the night in assisting the stage management of the night advance, but few can be spared for such rudimentary, though honorable, duties as wire cutting and such like at the head of the assaulting columns.

In siege warfare the conditions are different. Here the obstacles are more formidable, and the task of driving avenues of approach into the heart of the enemy's works requires highly technical skill and training. In this the engineers will take a prominent part, and the divisional companies will be largely reinforced "by units specially trained in the work of sapping and mining."

In a *retreat* the duties of engineers are multiplied. The rear guard must have its contingent to assist in making demolitions and obstructions in its rear. Incidentally it may be suggested that supplies of explosives for their use may be left with the food and ammunition on the roadside to be picked up *en route*. The head of a retreating column can not safely be left without an engineer party to remove incidental obstructions in its path. There is also important work for engineers in the preparation of rallying positions. Here it is possible that help may be required by the artillery, both to give access to positions from which the best tactical results can be obtained, and also in view of retirement to save them from becoming entangled in a difficult country.

In *defence* the uses of engineers are well known in the preparation of a defensive position, but it should be borne in mind that it is better to concentrate the sappers in the more important pivots than to scatter small parties in an attempt to give engineer assistance to every pivot. The question arises: Should the engineers be left indefinitely to share in the defence of the pivots to which they are allotted? It is true that the defence work on a pivot can hardly ever be said to be completed. The very conditions of defence of these strong points require that no efforts should be spared to render them impregnable; and yet one would not wish to see the few engineers who are included in the establishment of the army allowed to be involved in the defence, and thereby lost to the more important work of the counter-attack.

This same question may occur in all defence work in the occupation of *points d'appui*. In the case of an advanced guard it can not be helped. They dig themselves in in the face of the enemy, it is fighting from the first and all the force will necessarily become inextricably involved. In other cases they should be withdrawn, and the decision as to when they should be withdrawn must depend upon circumstances. They will seldom be able to put the finishing touches to their work, but none the less it is conceivable that they will upon occasions become involved in serious fighting.

Their normal place is with the local reserve of the attack. They are not in sufficient numbers to be everywhere and they are essentially troops belonging to the attack and should not be expended in local defence.

Discussion: Military Survey of Oahu*

BY

Capt. R. T. WARD
Corps of Engineers

I was in command of ''A'' Co., Engineers, and commenced the survey in 1908 and was actively connected with the work until February, 1912. I feel largely responsible for the methods adopted during this period. Before leaving Honolulu I submitted to Major Wooten, Corps of Engineers, District Engineer and Battalion Commander, a detailed report upon the survey and the land defense project for the information of ''I'' Co., Engineers. This report covered for the survey as a whole: reasons for and development of methods used, and for each individual sheet; history, conditions under which different parts were surveyed, errors found, difficulties encountered and relative accuracy of the work. In general, the methods in use in 1912 were followed by ''I'' Co. and were systematized and the record keeping much improved. The following remarks are mainly compiled from my report of 1912, and endeavor to cover a little more in detail certain points mentioned in Lieutenant Besson's article.

GENERAL CONDITIONS.

''A'' Company first had to establish a post at the recently purchased ''Waikiki Military Reservation,'' later called Fort De Russy. A large amount of construction work was done by both ''A'' and ''G'' companies. The survey had to be conducted and all the departments of a military post administered. The battalion non-commissioned staff performed all the post non-commissioned staff duties, but a large number of good men had to be drawn from the companies as a good many men are needed to administer a post, no matter what the size. During the latter part of this period a post quartermaster sergeant was available. All detachments were supplied from the main camp at Fort De Russy. In a good many ways it would have been better if the Engineers had been stationed at Fort Shafter from the beginning—the only post on the island in 1908.

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*This article, by Lieut. F. S. Besson, Corps of Engineers, appeared in No. 28 of Professional Memoirs.

Upon arrival in Honolulu no orders were found relating to the work and no copy of the project was available. It was known that Colonel Haan, C. A. C., had made a preliminary report upon the land defense and had recommended that a company of engineers be sent to make a survey. About a month after landing I obtained, from Major Dunning of Fort Shafter, a member of the Land Defense Board, his copy of Colonel Haan's report which had been submitted to the Adjutant General of the Army, May 15, 1908. The following extract is taken.

> * * * recommendations:
>
> 1. That a company of engineer troops be sent to Honolulu, H. T. and directed to make accurate maps on a scale of not less than 500 yards to the inch of certain areas of land in the vicinity of proposed fortifications and camp sites. The locations of the areas to be mapped are indicated on the enclosed chart. Enclosed is also a memorandum showing the details that are to be noted on the maps, etc.

Other work recommended to be done was: locate earthworks indicated; make working drawings and estimates of cost; investigate water supply; examine mountains for possible passes and make recommendations for additional defensive measures. In general, the usual requirements of a land-defense project. These requirements are well discussed in Capt. L. H. Watkins' article on "Map Making," in PROFESSIONAL MEMOIRS No. 28.

"A" Co., with which I had been serving since September, 1907, had been engaged for about a year previous upon work of this sort upon Colonel Haan's projects relating to San Francisco and San Diego. I knew what Colonel Haan desired. All maps and reports were to be sent to Colonel Haan, who was to make the final report.

Work was started in December upon the sections of the island covered by this project. It was understood that this was all the work that was to be done, and an effort was made to complete it as soon as possible. For this work a flat projection was adopted and the line of redoubts with country to the front surveyed—country to the rear and not mentioned in the project was put in by reconnaissance methods for a short distance in order to show the general nature of the terrain. When this work was nearly completed it was decided that a good map of the whole island would be needed, as other lines would have to be considered and studied. The work on the general map was commenced by "G" Company.

REASONS FOR METHODS.

Practically all the work was done by enlisted men under the supervision of officers. This included instrument work, drafting, and sketching. It was found possible to teach men to run an instrument, to sketch around a station, and to run a short traverse line accurately, but it was practically impossible to teach them to understand and apply the various checks, adjustments, and short cuts which a trained surveyor uses. Methods had to be adopted that would make mistakes less liable and more apparent. This made the work slower than it would have been had enough officers or trained surveyors been available to sketch for each instrument. Four officers were not enough to carry on the survey in any other way. A large part of the time was spent in instruction. In teaching new men to sketch or run an instrument, whenever possible they were given country that had not been covered, so that their work if good could be used. I found that men learned much quicker in this manner than when working on mere practice sheets. Very little work by new men had to be done over, but the progress was, of course, slow. The poor work was generally done by men whose enlistment was nearly up and who were inclined to be careless. The enlisted men of "G" Co. had been engaged upon the Cuban survey. It took them some time to get accustomed to the more detailed methods in use in Oahu. They judged their work by the number of miles covered a day and not by the real test: Whether the map faithfully represented the ground on the scale used with the details necessary. It would almost seem that their Cuban experience was more of a drawback than a help. Later they erred the other way and obtained too much accuracy, which for this work was considered preferable.

Nearly all the men of "G" Co. had less than two years to serve upon arrival in Oahu. Most of the experienced men were lost by March, 1911, and in June the company was filled by recruits not generally fitted for the engineer service. Very few men reenlisted in Honolulu, so the personnel of the parties was constantly changing. Some men transferred and some purchased their discharge and received employment as surveyors upon the plantations. The result was that often by the time a man understood the work well he would be replaced by a new man. A system that could be quickly learned and admitted of little error had to be adopted. Great interest was taken in the work and the men worked willingly and well. The work was hard—very much harder than the work the other soldiers in the island did and the pay was the same and the responsibility great, and it is not surprising that the men did not reenlist. Many "G" Co. men were in the field nearly three years and often in camps where drinking water had to be packed, and where rains fell most of the time.

When the work was first started the method of stadia, transit, and note-book was used, the work being plotted at night. "A" Co. understood this method. It was found with a little practice that men were able to plot their work very accurately in the field. In order to facilitate plotting, secondary stations were taken nearer together, sketching tables and boards devised and gradually the method of plane table, transit and stadia was adopted, and when "G" Company arrived they were taught this method. Field sketches were transferred to field sheets with little or no adjustment by the judicious selection of sub-triangulation stations. This method of surveying is described in detail by Capt. L. H. Watkins in his article in PROFESSIONAL MEMOIRS No. 28 referred to above, and more briefly by Lieutenant Besson and Captain Hannum in "Military Survey of Oahu."

SCALE.

The scale 1-18000 was considered fixed according to the directions for the survey. It was one that had received Colonel Haan's approval on previous work. The map was intended primarily for a land-defense map. Many details not ordinarily placed on military maps were required and considered necessary. For other uses it was the intention that the map should be issued on a smaller scale. It was not known how much or what sections of the island would be needed in the study of redoubt location. Military scales were not covered by orders at that time; if they had been one would certainly have been adopted for the sake of uniformity, even though the scale might not have been the best for the work to be done and the country to be covered. It was found that much better results were obtained by using larger scales for the field work. My draftsmen could place on the 1-18000 scale practically all the details that the men in the field could place on a 1-6000 scale sketch. Drafting in the field was difficult, as the work was done often under bad conditions and very fine work with the pencil was impossible. Small detail work is very hard for the average enlisted man in the field. When the attempt was made to use the 1-18000 scale in the field the map obtained was generally bare of detail and sections covered by this scale and placed on the finished sheet showed up badly in comparison with the work reduced from larger scales. I consider that the poorest work upon the survey was done when the 1-18000 scale was used.

The effort was made to include nothing on the final sheets that was not obtained from field sketches made directly from the ground. Most enlisted men are not naturally adept at drawing. An attempt to place many details on a small scale sheet in the field generally results in confusion and in effect a lack of detail.

I do not believe that a map could have been made within one year, even with a picked engineer company, unless most of the island was sketched, as it is nearly all rough and a large section is high and usually covered with clouds. I believe that a map of this sort drawn originally on a much smaller scale by enlisted men would not have been sufficient for land defense purposes.

An attack upon Oahu would hardly be made by any force unless they considered they would be able to land and have good chances of capturing Pearl Harbor. It would seem that the garrison might be placed on the defensive and even forced to stand a siege and in this case it would be difficult to say which portions of the island would finally become very valuable from a military point of view. In working out a project it is advisable to consider all possible situations, even the final stand of the garrison in the vicinity of the navy yard or Honolulu. It was decided to draw the map on a relatively large scale and as accurately as possible in the beginning, rather than attempt a make-shift by rapid sketching and then be continually occupied by making more accurate surveys of certain portions. For land defense study a relief map would be useful; an excellent one could be made from the present map. The various lines and defensive positions should, of course, be located on the ground after a careful study from both the defender's and attacker's points of view. It is very probable that the officers who finally have to pass upon the project will have to make their decision from the maps and reports submitted. It would seem that a carefully surveyed large scale map accompanied by photographs and terrain descriptions would tend to insure the project being understood by all persons concerned and a proper decision being made.

THE PLANE TABLE.

My experience with enlisted men has been that they do more accurate and more rapid work using the transit, stadia, plane table method and I also find that the resulting map can better stand close comparison with the ground. The sketcher is not bothered with reading the instrument, his eyes are not tired by continually changing from telescope to sketch; he is free to look at the country that he is mapping; he can often detect errors in azimuth reading and in distance given by the transit man and recorder, and for the majority of side shots the transit man needs only to read the distance and the vertical angle as the sketcher points his scale at the place and plots the point. The table used is very light and can be easily set up. The sketcher can easily shift his position to obtain a better view and can utilize reconnaissance methods with transit control. The transit is quicker to set up than the plane table and the adjustments are in a way easier. The continual shifting of the telescopic alidade tends to dirty the sketch and delay the making of the sketch. In cases of doubt the sketcher can consult with his transit man and recorder and they check each other. It is difficult to ''fake'' work with this method, as two or three men must work together. This is sometimes attempted by enlisted men, but is of rare occurrence. The plane table reduces the party by one and, sometimes, two men. With enlisted men this is not a great advantage and the work will probably be slower and less accurate. The number of parties, no matter what method is used, depends upon the number of sketchers available, as there are always plenty of men who can record and use a transit, or who can be taught. It is difficult to teach a man to ''see contours'' unless he has the natural aptitude. I believe that it takes a better knowledge of trigonometry and the theory of surveying to use the plane table than it does to use the transit and sketching table.

It is necessary to consider the ability of the men who are to do the work, the number of instructors available, the nature of the country to be mapped, the detail desired, and the purposes of the map and then adopt whatever method gives the best results. In Oahu an attempt was made to adopt a method that would give the most accuracy, insure the most detail, be easiest for the men and, in fact, be the most ''fool-proof.'' In the hands of trained surveyors and on small scale maps with enlisted men and in more or less open country the plane table has marked advantages. Good work can be done by both methods.

SIZE OF SHEETS.

The size of the sheets was determined by the scale and the desire to include the island upon as few sheets as possible, but upon sheets which were not too large for convenient *office use.*

The size was adopted after careful consideration and much experimentation. For general use it was assumed that the maps would be issued upon a smaller scale, reduced possibly by photographic methods and later lithographed or engraved in colors.

CONVENTIONAL SIGNS.

The sheets drawn for Colonel Haan's project were in colors. Prints made from these sheets were very unsatisfactory and so when it was decided to map the whole island it was not thought advisable to use colors on the finished tracings, but to use black and so indicate the topography that confusion would not result. Continual calls were made from the very beginning for the portions of the map that were finished or partially finished. The fact that the map was drawn in black, that the tracing was done in most cases by men with no experience in drawing and that large sections of the island were covered with vegetation peculiar to the island led to the adoption of a few conventional signs different from those shown in manuals. Water lines were not used, as I find them the most difficult sign for an inexperienced draftsman to execute—the usual result is the ruination of an otherwise good piece of work. On a map drawn in black, water lines can be confused with hill forms and was done by certain of the users of blue-prints made from the maps drawn for Colonel Haan's project. Ruled lines can never be confused with any other sign. I also believe they are the logical sign, as the water in swamps and marshes is represented by lines.

LETTERING.

It is unfortunately true, as Captain Downing writes, that the care with which the lettering is done is not infrequently taken as a fair indication of the reliability of a map. I have seen many maps and drawings where the lettering consumed much more time and brain work and was far more accurate than the map or drawing itself. I believe that the only test is actual comparison with the ground. A man should be able to locate himself easily, not from names of places, but from the contours and topography of the map. Men experienced in map making can generally tell whether a map is good from the appearance of the hill forms.

Lettering is very difficult for the enlisted man—indeed, for many draftsmen—and the use of type is becoming general. The method used by "I" Co. should have given satisfactory results. The square letters previously adopted were considered satisfactory for the land-defense map. I have taught a man to use square letters well in a few hours—a man who could not begin to make the letters laid down in our manuals. Simpler letters, I believe, are needed for ordinary military work—good free-hand letterers are scarce among enlisted men.

My intention was to use as little lettering as possible on the sheet itself, but to use marginal letters and numbers. With each sheet there was to be submitted a detailed report containing such information as character of roads, bridges, buildings, water supply, villages, soil, stores, etc. This was to be supplemented by photographs carefully selected. The report was to be kept up to date and revised from time to time. I do not know whether this idea was adopted by "I" Company.

PERMANENT MARKS.

There are plenty of permanent marks upon Oahu. The trig. points of the Alexander survey consist of a heavy concrete base about 5 feet square, in which is embedded a galvanized iron pipe upon which there is a locked can.

PROJECTION AND COORDINATES.

The reasons for the projection adopted are well covered by Lieutenant Besson and Captain Hannum. The coordinates were first computed by Major Putnam in the summer of 1909, using the method given in Wilson's Topographical Surveying, 1904, Table XXIII. Arithmetical coordinates were used for simplicity. Of the thirty or more men employed as sketchers at various times, only two or three had enough education to understand and apply spherical trigonometry. I believe that it would have been hopeless to have attempted to teach the men how to compute the geodetic positions and to expect accuracy. By rule-of-thumb application of a few simple formulæ of plane trigonometry nearly every man could compute and plot a sub-station accurately. The X and Y are computed from both ends of the base and the station plotted and checked by angle and distance. Except in cases of exceptional men, only minor stations were left to the enlisted men. The usual method employed was a system of adjusted quadrilaterals based upon triangulation of the island survey—the computations being made by an officer. The more control points the better. If it is possible to so arrange the work that all traverses are short and begin and end on known stations, many errors and adjustments will be avoided. In large scale work in the vicinity of Honolulu I found that I gained time and accuracy by first having control traverses run before the sketching was done from the traverse. The sketch would then be traced and inked directly upon the field sheets, no adjustment being needed. The field sheets were kept in water-tight tubes and all stations were accurately plotted upon them by means of coordinates. Traverses were not plotted by coordinates.

INSPECTION.

In my opinion, too much emphasis can not be placed upon the map being a faithful representation of the ground. Nothing should be added to the field sheet in the office except the lettering and certain carefully made and carefully placed conventional signs. Frequent and careful comparison should be made by the officer in charge of a party of the field sheet and the ground. The poorest work on the Oahu survey I attribute principally to either no, or very lax, inspection. Except for a few refinements of drafting, the field sketch and the field sheet should be the finished map and any office improvement generally means inaccuracy.

CONCLUSION.

If work of this sort is again ordered it would be a great help if definite orders were given as to the work to be done a sufficient time in advance to permit an officer of the company to be sent to the locality to become familiar with the ground, to study the situation, to prepare and recommend a scheme of operations and to arrange for quarters and supplies. If possible, the company or detachment detailed for the work should be kept on the job until it is finished and the men should have nearly a full enlistment to serve when the work is started.

Quincy Adams Gillmore*

BY

First Lieut. F. S. STRONG, Jr.
Corps of Engineers

Quincy Adams Gillmore was born at Black River, Loraine County, Ohio, in February, 1825. He entered the Military Academy at West Point in 1845, graduating at the head of his class in 1849, and was assigned to the Corps of Engineers as brevet second lieutenant.

One of his first duties was as assistant engineer in the construction of Fort Monroe, Va., while from 1852 to 1855 he served as assistant instructor of practical military engineering at West Point. In 1853 he received his commission as second lieutenant, and in 1856 became first lieutenant. From 1857 to 1859 he was in charge of the fortification work in New York Harbor.

Being advanced to the rank of captain in August, 1861, he was made chief engineer of the Port Royal expedition. He quickly rose to prominence as a military engineer in connection with the reduction of Fort Pulaski, in Savannah Harbor, Georgia. Various plans had been suggested looking to the capture of this work, which was located on a marshy island, but it remained for Captain Gillmore to conceive one promising success. He was accordingly given complete charge of the operations, the salient feature of which was the massing of powerful batteries of mortars and rifled guns on Tybee Island, a mile distant from the fort. After two months of preparation, the bombardment was begun, lasting until the surrender of the fort thirty hours later. The signal success of the young engineer officer brought him immediate fame and advancement, he being brevetted lieutenant colonel, and appointed brigadier general of volunteers.

In August, 1862, General Gillmore was assigned to the command of a division in Kentucky, and was in charge of the Federal forces in the Battle of Somerset, defeating the Confederates under General Pegram. He was brevetted colonel for gallantry in this action.

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*See frontispiece.

In June, 1863, he was placed in command of the Department of the South, and the following July, of the Tenth Army Corps. While holding this command he conducted the operations against Charleston, comprising the descent on Morris Island, the reduction and capture of Fort Wagner, and the bombardment and practical demolition of Fort Sumter from batteries 2 miles distant. For this excellent work he was later given the brevet ranks of brigadier and major general. General Halleck, in commenting upon this campaign, said: ''General Gillmore's operations have been characterized by great professional skill and boldness. He has overcome difficulties almost unknown in modern war sieges; indeed, his operations at Morris Island constituted a new era in the science of engineering and gunnery.'' General Gillmore was now commissioned major general of volunteers.

He was transferred to the James River in 1864, commanding the Tenth Corps at Drurys Bluff in May of that year. In July he was summoned to Washington to command two divisions of the Nineteenth Corps, on the approach of General Early, and in the subsequent pursuit of the Confederates after their unsuccessful attempt at capturing the city. During this pursuit he suffered serious injuries in a fall from his horse, and was incapacitated for active service till the following September. From February till November, 1865, he commanded the Department of the South, finally resigning his volunteer commission in December of that year.

General Gillmore was commissioned major, Corps of Engineers, in 1863; lieutenant colonel in 1874, and colonel in 1883. After the war he was engaged in many important duties of an engineering nature, including the presidency of the Mississippi River Commission. During this time he also published various works of a military character, besides several treatises on technical subjects.

During the last years of his life he was a constant sufferer, but never gave up his duties. He died in Brooklyn, N. Y., in April, 1888.

General Gillmore's life and professional distinction mark him as one of the most eminent officers of the Corps of Engineers: a leader in the military as well as in the engineering profession.

Editorial Note

Prizes for Articles for 1915

For articles published in Numbers 31-36, inclusive, comprising Volume VII, the PROFESSIONAL MEMOIRS will award four prizes as follows: Fifty dollars for the best article; twenty-five dollars for the second best; fifteen dollars for the third; and ten dollars for the fourth.

This offer is open to all subscribers to the PROFESSIONAL MEMOIRS, except officers of the Corps of Engineers with more than ten years' commissioned service in the Corps. The School Board of the Engineer School will be judges.

Articles of any length may be offered in competition for these prizes. Their length *per se* will not be a factor in determining the successful competitors. However, an article containing more matter of value, facts or opinions, etc., will be rated higher in the contest than a shorter and less comprehensive article. Professional excellence, clarity, and conciseness are considered of prime importance, though literary excellence will be considered in making the award. In addition to the above prizes and in accordance with the precedent of the past three years, one year's free subscription will be given to each author of an article of twelve pages or more, if that article be not awarded one of the four prizes above mentioned.

PROFESSIONAL MEMOIRS
Corps of Engineers, United States Army, and Engineer Department at Large

INDEX TO VOLUME VI.

JANUARY-DECEMBER, 1914.

I. Authors.

Page

ABBOT, FREDERICK V., Colonel, Corps of Engineers; M. Am. Soc. C. E.
  Concrete in Sea Water on New England Coast 111-118
  Discussion on Concrete 129-130

ALTSTAETTER, F. W., Major, Corps of Engineers; M. Am. Soc. C. E.
  Reversed Parker Bear-Traps, Dam No. 13, Ohio River 504-525

BABCOCK, HENRY NASH, Assistant Engineer.
  Enlargement of Governors Island 410-422

BAIN, JARVIS J., Lieutenant, Corps of Engineers.
  Cost Data for Concrete and Metal Fences 236-240

BESSON, F. S., Lieutenant, Corps of Engineers.
  Military Survey of Oahu 445-461
  Discussion: Military Survey of Oahu 487-488

BLACK, W. M., Colonel, Corps of Engineers.
  Discussion on Concrete 128-129

BLACKBURN, N. T., Junior Engineer.
  Repairing Leaks in an 8-inch Water Main 40 Feet Under Water in Galveston Harbor, Texas 553-559

BOND, P. S., Major, Corps of Engineers.
  Discussion: Military Survey of Oahu 478-484
  Use and Development of Ponton Equipage 692-758

BOWDEN, NICHOLLS W., Junior Engineer.
  Improving Tennessee River above Chattanooga, Tenn., by Regulation or Open Channel Method 663-691

BURGESS, H., Major, Corps of Engineers; M. Am. Soc. C. E.
  Discussion: Reversed Parker Bear-Traps 526-536
  The Colbert Shoals Canal, Tennessee River, Alabama 69-101

CAPLES, W. G., Major, Corps of Engineers.
  Development of Explosives for Our Demolition Equipment 604-614
  Light Bridge Equipage 256-268
  Reconnoissance Equipment 759-779

CRAIGHILL, W. E., Lieutenant Colonel, Corps of Engineers.
  Concrete Where Exposed to Sea-Water or Frost 119
  Introduction to, "Engineers with Sherman's Army" 358-359

DALEY, E. L., Captain, Corps of Engineers.
  The Modern Siege .... 182-[illegible]

DOWNING, FREDERICK B., Captain, Corps of Engineers.
  Discussion: Military Survey of Oahu 485-486

Page

DUNN, B. C., Lieutenant, Corps of Engineers.
  Maj. Gen. Montgomery Cunningham Meigs 537-538

DURHAM, C. W., Principal Assistant Engineer.
  Winter Work in the Construction and Repair of Dams and Shore Protections in the United States Improvement of the Upper Mississippi River 651-660

ERNST, OSWALD H., Brig. Gen., Corps of Engineers; M. Am. Soc. C. E.
  Biography of Gen. Charles Walker Raymond 232-235

FRIES, AMOS A., Major, Corps of Engineers; M. Am. Soc. C. E.
  The Battle Sight 131-132

HANNUM, WARREN T., Captain, Corps of Engineers.
  Discussion: Military Survey of Oahu 462-478

HOLBROOK, FRANK D., Assistant Engineer; M. Am. Soc. C. E.
  Concrete and Metal Fences 236-241

HOWELL, GEORGE P., Major, Corps of Engineers; M. Am. Soc. C. E.
  On What Basis Should Recommendations for a Waterway Improvement Be Made? 228-231

HUBBARD, JAMES M., Major, Twelfth Missouri Cavalry.
  Engineers with Sherman's Army 358-394

MARSHALL, W. L., General.
  Cylindrical Valves and Automatic Crests of Dams 395-402

McDONOUGH, M. J., Major, Corps of Engineers.
  Discussion: Military Survey of Oahu 478-484
  Use and Development of Ponton Equipage 692-758

McGLONE, R. G., Junior Mechanical Engineer.
  The Teredo in Fresh Water 560-561

MEHAFFEY, JOSEPH C., Lieutenant, Corps of Engineers.
  William Farrar Smith 649-650

MILLIS, JOHN, Colonel, Corps of Engineers.
  Discussion on Concrete 130

OAKES, J. C., Major, Corps of Engineers; M. Am. Soc. C. E.
  Flood Prevention 423-438
  Works at the Falls of the Ohio River, Louisville, Ky. 563-603

OSANN, HERMANN E., Late Chief Lithographer, Army Service Schools.
  Field Methods for Printing from Metal 321-332

PATRICK, M. M., Lieutenant Colonel, Corps of Engineers; M. Am. Soc. C. E.
  Damage to Lining of Filling Tunnel, Poe Lock, St. Marys Falls Canal 549-552
  Some Damage by the Lake Storm, November, 1913 333-344

PEEK, ERNEST D., Captain, Corps of Engineers.
  Duluth-Superior Harbor 139-181

PERRY, R. B., Junior Engineer.
  Damage to Harbor Works, Cleveland, Ohio, by Lake Storm, November, 1913 345-347

Page
Poe, O. M., General.
Engineers with Sherman's Army ____________________________ 358-394
Pope, F. A., Major, Corps of Engineers.
Road and Trail Construction in Alaska______________________ 275-320
Potter, Chas. L., Lieutenant Colonel, Corps of Engineers.
An Ice Cofferdam_______________________________________ 439-440
Reinecke, P. S., Lieutenant, Corps of Engineers.
Biography of Alexander Dallas Bache______________________ 408-409
Schulz, Edward H., Major, Corps of Engineers.
The U. S. Sea-going Suction-Dredge, "New Orleans"________ 631-643
Sherrill, C. O., Captain, Corps of Engineers.
Discussion: Military Survey of Oahu_______________________ 484-485
The Port of New Orleans___________________________________ 1-47
Skey, F. E. G., Lieutenant Colonel, Royal Engineers.
Tactics of Divisional Engineers____________________________ 770-774
Sohlberg, O. N., Lieutenant, Corps of Engineers.
Tank Car, Water Supply for Troops on the March__________ 403-407
Strong, F. S., Jr., Lieutenant, Corps of Engineers.
Biography of Quincy Adams Gillmore______________________ 784-785
Taylor, Harry, Lieutenant Colonel, Corps of Engineers; M. Am. Soc. C. E.
Cost of Government Dredging vs. Contract Dredging________ 242-243
Ward, R. T., Captain, Corps of Engineers.
Discussion: Military Survey of Oahu ______________________ 775-783
Notes on Water Hyacinth___________________________________ 644-648
Watkins, Lewis H., Captain, Corps of Engineers.
Map Making in Connection with Land Defense for Seacoast Fortifications and Seacoast Cities_________________________ 489-503
Watt, D. A., Assistant Engineer; M. Am. Soc. C. E.
Concrete Laid in Freezing Weather, New York Barge Canal____ 124-127
Wilby, F. B., Captain, Corps of Engineers.
Tests of Bangalore Torpedo_________________________________ 102-110

II. Titles and Subjects.

Page
Alaska—
Road and Trail Construction in____________________________ 275-320
Road Commission____ 282-286
Battle Sight ____ 131-132
Biographical Notes—
Bache, Alexander Dallas ____________________________________ 408-409
Gaillard, David Du Bose, Lieutenant Colonel, Corps of Engineers. 133-134
Gillmore, Quincy Adams _____________________________________ 784-785
Meigs, Montgomery Cunningham, Major General_______________ 537-538
Raymond, Charles Walker ____________________________________ 232-235
Smith, William Farrar ______________________________________ 649-650

Breakwaters— Page

Damage to, by Lake Storms, November, 1913 333-356

Duluth-Superior Harbor 165-168

Bridges—

Duluth-Superior Harbor 176-178

Louisville Bridge 584-585

New Bridge at Head of Locks at Louisville 586

Taslina Bridge, Alaska 310-312

Bridge Equipage—

Light Bridge Equipage 256-268

Use and Development of Ponton Equipage 692-758

Camps—

Students' Summer, Military 444

Canals and Canalization—

Cascades Canal, Columbia River, Oregon 246

Central Canal, Duluth-Superior Harbor 168-170

Colbert Shoals Canal, Tennessee River 69-101

History of Louisville Canal 564-603

New Welland Ship Canal 222-227

Present Canal at Louisville 578-580

Widening Louisville Canal 580

Cofferdams—

An Ice Cofferdam 439-440

Concrete—

Concrete and Metal Fences 236-241

Discussion on Concrete Exposed to Sea Water or Frost 128-130

In Sea Water on New England Coast 111-118

Laid in Freezing Weather 124-127

Where Exposed to Sea Water or Frost 119-123

Costs—

Bear Trap at Dam No. 13 510

Canal near Fort St. Phillip 7

Colbert Shoals Canal 84-97

Concrete and Metal Fences 236-240

Dredging, Government vs. Contract 242-243

Enlargement of Governors Island 410-422

Improvement in New Orleans Harbor 28-33

Jetties at New Orleans 17-19

Louisville Canal and Improvement 564-566

Repairing Leaks in Water Main 559

Suction Dredge ''New Orleans'' 631

Taslina Bridge, Alaska 311-312

Valves in Louisville Locks 594

Widening Louisville Canal 582

Winter Repair Work in Upper Mississippi 651-660

Damage to Vessels and Property— Page
By the Lake Storm, November, 1913 333-357
Government Works 338-344
Harbor Works, Cleveland, Ohio 345-357
Prevention of Damage by Floods 434-438
Shipping 333-338

Dams—
At Head of Louisville Canal 572-577
Boulé Emergency Dam at Louisville 585-586
Comments on the Reversed Parker Bear-Trap and the Two-Leaf Type of Weir 518-524
Cylindrical Valves 395-398
Disadvantages of Reversed Parker Bear-Trap Weir 510-517
Discussions of Reversed Parker Bear-Trap Weir 526-536
Failure of Stoney River Dam 272-273
Movable and Automatic Crests 398-402
The Reversed Parker Bear-Trap Weir, Dam 13, Ohio River 504-510
Winter Repairs to Dams in Upper Mississippi 651-660

Dikes—
Longitudinal vs. Wing or Spur Dikes 672

Docks—
Duluth-Superior Harbor 158-162

Dredging—
Cost of Government Dredging vs. Contract Dredging 242-243
Details of Suction Dredge "New Orleans" 631
Duluth-Superior Harbor 175-176
In Front of Sea Wall at Governors Island 433-434
Use of, in Prevention of Floods 433-434

Engineers—
With General Sherman's Army 358-394

Explosive—
Use of Trinitrotoluol for Demolitions 604-614

Field Fortifications—
Offensive Infantry Work 628-629
Orders for and Examples of Intrenching 617-627
Plans for 616-617
Technical Artillery Works 627
Use of Sand-bags 629-630
War Experiences 615-616

Floods—
Effect of Forests on 425-427
Maximum Flood Discharges 250-255
Prevention of 423-438
Prevention of, Damage by 434-438
Use of Dredging in Prevention of 433-434
Use of Levees in Prevention of 433
Use of Reservoirs in Prevention of Floods 427-432
Island of Oahu 462-469

Harbor Works— Page
- Damage by Lake Storm 345-357
- Duluth-Superior Harbor 139-181
- Notes on Rivers and Harbor Works 244-248

Land Defense Project 489-491

Levees—
- Use of, in Prevention of Floods 433

Locks and Lock Gates—
- Damage to Lining of Filling Tunnel, Poe Locks 549-552
- Details of Lock Valves at Louisville 590-595
- Details of Gates, Louisville 595-602
- Louisville Locks 567-570
- New Locks at Louisville 586-590

Maps—
- Autographic Transfer Process 326-328
- Construction of Maps for Land Project 494-503
- Field Methods of Printing from Metal 321-332
- Hectograph 330-331
- Need of Maps in Connection with Land Defense Project 491-494
- Photolithographic Process 322-326
- Reversal Process 328

Material—
- Equipment for ''New Orleans'' 635
- For Intrenchments 625
- For Louisville Canal 504
- For Operating Locks 602-603

Night Fighting and Outposts 48-68

Obstructions to Navigation—
- Ohio River, On 563
- Water Hyacinth 644-648

Pontoniers—
- Raid of Wilson's Cavalry in Northern Alabama in 1865 393-394

Reclamation—
- Enlargement of Governors Island 410-422

Reconnaissance Equipment 759-769

Repairing—
- Leaks in an 8-inch Water Main, 40 Feet Under Water 553-559

Reservoir—
- Regulation of Level 401-402
- Use in Prevention of Floods 427-432

Rivers—
- Bars and Passes in the Mississippi River 7-22
- Faults of River Banks 34-36
- Improving Tennessee River above Chattanooga by Regulation or Open Channel Method 663-691
- Jetties in Port of New Orleans 17-22
- Notes on River and Harbor Work 244-248

Rivers—Continued.

	Page
Port of New Orleans	1-47
Project for Ohio River	577-578

Roads—

Road and Trail Construction in Alaska	275-320
Work of Army in Construction of Roads	539-548

Sea-Walls—

Enlargement of Governors Island	416-419

Siege—

Defense Against Siege	210-217
Modern Siege, The	182-221

Surveying—

Discussion: Military Survey of Oahu	469-488
Military Survey of Oahu	445-462 775-783

Table of Engineer Districts	136

Tactics—

Divisional Engineers	770-774

Terminals—

New Orleans	36-47

Tests—

Dredging Tests of "New Orleans"	639-643
Torpedo, Bangalore	102-110
Teredo in Fresh Water	560-561

Water Supply—

For Troops on the March, Tank Car	403-407

Waves—

Duluth-Superior Harbor	152-155

Waterways—

Basis of, Recommendation for Improvement	228-231

Errata

Page 244, third line, instead of "a ¼-inch spike," read "a 1¼-inch spike." The inside diameter of the pipe was 22 inches.

Page 100, strike out last paragraph.

SUPPLEMENT No. 1
PROFESSIONAL MEMOIRS
MARCH-APRIL, 1914
Vol. VI, No. 26

BIBLIOGRAPHICAL CONTRIBUTIONS
BULLETIN No. 1

The War with Mexico
1846–1848

A Select Bibliography on the Causes, Conduct, and the Political Aspect of the War, together with a Select List of Books and other printed Material on the Resources, Economic Conditions, Politics and Government of the Republic of Mexico and the Characteristics of the Mexican People.

With Annotations and an Index.

Published for, and Dedicated to, the Officers of the
United States Army and Navy

By

HENRY E. HAFERKORN
Librarian, United States Engineer School

WASHINGTON BARRACKS, D. C.
1914
Price, 50 Cents

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By Henry E. Haferkorn

Prefatory Note

It has often occurred to me that there is an absence of a convenient and descriptive guide to the Literature of that period of American history, the Mexican War, during which a great number of our brilliant soldiers stood their fire-test. It will likewise be noted, that in searching biographies of the well-known chieftains, very few pages are devoted to their services in the Mexican War.

With the exception of Prof. Soley's paper[a], the notes in Larned's[b], and in Bancroft's history[c], very few critical or descriptive accounts have been discovered.

It is true, as Lawson[d] states in his Essay, that the greater number of histories, narratives and lives were written soon after the close of that war, when the mass of documentary and other material which time has now made accessible, were not available to their authors.

In the case of General Z. Taylor the late Prof. Soley[a] states: ''Of Taylor we have no considerable or well-studied account, and we must depend upon official and other sources for this part of the war.''

The facts above stated have influenced me to attempt a selection from the abundance of material available, and arranging it in convenient order so as to make it helpful to the student, more particularly the military student.

As no exhaustive record of the available material was contemplated, neither are the references to persons, places and topics found in the index exhaustive, they are intended only as guides to further study and search.

I am under obligation to the publishers of ''Winsor's Narrative and critical history of America'' for permission to use the foot-notes of Prof. Soley, on whose paper: ''The Wars of the United States, 1789-1859,''[a] my selection of titles has been based, and to the Publishing Board of the American Library Association, allowing me to use the foot-notes of the late Josephus Nelson Larned found in his ''Literature of American History.''[b]

The short essay by Lawson[d] was of some help to me, and this, together with Soley, Larned, Bancroft, and the critical articles by Hamilton and Lane (titles of the latter will be found on p. 13, 16) is recommended for study to the military student.

I have appended a short list on ''Modern Mexico,'' believing the same to be of general interest.

Full title-entries, as preferred by the Library of Congress in cataloguing for their catalogs and bibliographies, were used, as far as possible, and a large number of books listed have been carefully examined and in part analyzed, more particularly for the benefit of readers remote from Library facilities.

Persons and libraries using the Library of Congress cards for their catalogs will find the serial numbers of these cards below the foot-notes, or below the title of each entry, on the left side. The number next to this is the call-number needed when borrowing books from the Library of Congress, and the initials on the same line, viz: A. W. C.; E. S.; W. D. show that a given book may be had from the Libraries of the Army War College, Engineer School, or War Department. The absence of such notes shows that the work is not found at present in any of the above-mentioned libraries in Washington.

The U. S. Congressional documents listed may nearly all be found in the libraries mentioned, in that case it is customary to use the ''serial-number'' as a call-number, and this will be found added to every entry.

Readers searching for Mexican material, and more especially for Mexican documents, are referred to the Bibliography on Mexico by the New York Public Library.[n]

While great care has been taken to avoid errors they may, however, be found, and readers who have studied the subject more exhaustively will confer a favor in calling my attention to the same.

The work herewith presented was performed out of office hours, and as a labor of love. It is intended, primarily, for the men in charge of our National defense with the hope that it may be of some assistance to them in the performance of their duties.

The following Bibliographies have been used, viz:

[c]BANCROFT, H. H. ''Authorities on the war'' in his: History of Mexico, v. 5, p. 551-556, and foot-notes in the same volume.

[d]LAWSON, WM. THORNTON. Essay on the literature of the Mexican war. [N. Y.? 1882] 21 p. 23cm. On p. 4 of cover: Columbia college, New York. Senior class essay, 1882.

Reviews Ripley's War with Mexico; Mansfield's The Mexican war; Brooks' Complete history . . . ; Frost's Pictorial history . . ., and gives a ''List of books on Mexican war'' (29 titles with short-form entries) at end.

9-7169 Z1241. L28

[b] . . . THE LITERATURE OF AMERICAN HISTORY. A bibliographical guide in which the scope, character, and comparative worth of books in selected lists are set forth in brief notes by critics of authority . . . Edited for the American library association by J. N. Larned. Boston, . . . Houghton, Mifflin & co., 1902. 1 p. l., ix, 596 p., 1 l. 25cm.

THE SAME. Supplement for 1900 and 1901; ed. by Philip P. Wells. ibid., 1902. 3 p. l., 37 [1], p. 25cm.

2-15885-5a Z1236. L32

[n]NEW YORK. Public library. List of works in the New York public library relating to Mexico. N. Y., 1909. cover-title, 186 p. 26cm.

''Reprinted from Bulletin, Oct.-Dec., 1909.''

Contents (in part).—Bibliography, p. [1]-3.—Public documents (Mexican), p. 8-41.—History and description, 1846-48: Mexican war, p. 80-87.—Special places, p. 105-127.—Biography, p. 140-144.—Railways, p. 150-155.

Ca10-78 Z1431 .N56

Pohler, Johann. Krieg der Vereinigten Staaten gegen Mexico, 1846-48. (In his: Bibliotheca historico-militaris. Systematische uebersicht der erscheinungen aller sprachen auf dem gebiete der geschichte der kriege und kriegswissenschaft, seit erfindung der buchdruckerkunst bis zum schluss des jahres 1880. Band 2. Leipzig, G. Lang. (Formerly, Verlag von Ferd. Kessler, Kassel), p. 510-514.

E. S.

[a]Soley, J. R. The wars of the United States, 1789-1850. (In Winsor, J. Narrative and critical history of America, edited by Justin Winsor. Bost., and N. Y., Houghton, Mifflin & co., [etc.] 1884-89. v. 7, p. 440-446).

.2-3986] E18 .W76

U. S. War department. Library. . . . Index to publications, articles and maps relating to Mexico in the War department library. Washington, Govt. print. off., 1896. v, 120 p. 29½cm. Its Subject catalogue no. 3.)

Issued originally in 4 parts with cover-title: Mexican bibliography.

Caption-title: List of books, pamphlets, reports, and other literature in the War department library relating to Mexico.

Mexican war, 1846-48, p .81-104.

''President's (Jas. K. Polk's) Messages relative to the Mexican war, to U. S. Congress. Arranged chronologically, p. 88-90.—Treaties, p. 92-93.—U. S. Laws pertaining to military affairs in connection with the war between the United States and Mexico, p. 98-100.—Texas and Texan affairs, p. 100-102.

1-27804 Z881 .Y611S E. S. A. W. C.

Order of Arrangement.

Page.

A. History of Mexico in general. A selection............ 1-7

B. General histories of the Mexican war, 1846-48, including also Studies of the war from a political standpoint 8-33

B. a. The Mexican war, 1846-48: Works relating to the Conquest of California and New Mexico.......... 34-39

C. Special campaigns and battles. Personal narratives. Regimental histories. 40-54

D. Biographical material. Lives of prominent characters of the Mexican war, including a few works relating to the former president, Porfirio Diaz............. 55-70

E. The Navy of the United States. Special works dealing with naval operations of the Mexican war........ 71-75

F. Modern Mexico. Including description of, and travel in, Mexico; natural resources, social life and customs, politics and government, economic conditions, the army and navy, and recent events in Mexico...... 76-89

G. Means of communication: Railroads, roads and trails, canals, inland waterways, rivers, seaports, posts and telegraphs, and other public works 90-93

Index, following p. [94].

Corrigenda:

P. 17. First line: Author's name is Ripley, Roswell Sabine; not Riley.

P. 67. Last line: Read Bixby; not Kirby.

A.

History of Mexico in General. A Selection.

Abbot, Gorham Dummer. Mexico and the United States; their mutual relations and common interests. New York, G. P. Putnam's sons, 1869. XVI, 391 p. front., port., map. 23cm.

A useful guide to the constitutional history, especially for the period from 1824-1859.

2-4897 F1226 .A12

Alaman, Lucas, 1792-1853. Historia de Méjico desde los primeros movimientos que prepararon su independencia en el año de 1808, hasta la época presente. Per Don Lucas Alamán . . . Méjico, Impr. de J. M. Lara, 1849-52. 5 v. front. (v. 5) plates, ports., fold. maps, plans, fold. facsims. 23½ cm.

Contents.—t. 1-4. Parte primera, que comprende desde el principio de las inquietudes en 1808, hasta la completa pacificación del reino en 1820 . . . Con una noticia preliminar del sistema de gobierno . . . en 1808, y del estado en que se hallaba el pais en el mismo año.—t. 5. Parte segunda, que comprende desde el plan proclamado por D. Agustin de Iturbide en Iguala, en . . . 1821 . . . hasta la muerte de este jefe y el establecimiento de la republica federal mejicana en 1824. Continuada hasta la época presente.

''Still a standard work, of considerable suggestive value, on the history of Mexico, and on the significant cause of events. Deals with the wars of independence, 1810-21, and with events during the period, 1821-1861.''—Soley.

2-5005 F1232 .A31

Bancroft, Hubert Howe, 1832- History of Mexico. San Francisco, A. L. Bancroft & co., 1883-88. 6 v. illus. (incl. maps) fold. maps. 24cm. (Works of Hubert Howe Bancroft, v. ix-xiv.)

v. vi pub. by The History co. According to W. A. Morris in Quarterly of the Oregon historical society, v. 4, p. 348-349, this was written under Bancroft's supervision by W. Nemos, T. Savage, J. J. Peatfield and one or two others.

"Authorities": v. 1, p. xxi-cxii.

Contents.—v. 1. 1516-1521.—v. 2. 1521-1600.—v. 3. 1600-1803.—v. 4. 1804-1824.—v. 5. 1824-1861.—v. 6. 1861-1887.

1-22959 E13.B21 F1226 .B2 A. W. C.

The same work. San Francisco, The History co., 1890. 6 v. illus., port., maps. 24cm. "Authorities": v. 1, p. xxi-cxii.

2-4900. F1226 .B21

. . . "Gives, [in v. 5, p. 362 et seq.] a more favorable idea of the Mexican side than we get from other American narratives, and [his] foot-notes display to us nearly all the important Mexican authorities on the subject.—Soley. cf. also, [his] Bibliography in v. 1.

"For details of Scott's campaign see v. 5, chap. 17, 18, 19, and final references p. 522.—Note on the losses of the army, v. 5, p. 544.—Palo Alto and Resaca de la Palma, May 8-9, 1846, v. 5, chap. 14, with plans and references.—Monterey, Sept. 19-24, 1846, chap. 15, and p. 378-381. cf. also: Historical magazine, v. 10, p. 207.—Buena Vista, Feb. 22-23, 1847, v. 5, p. 420, 433-436. He gives there also, a long list of American and Mexican authorities.—His account of the march of the Mormon battalion, v. 5, p. 477, is based on Tyler's concise history . . . (q. v.)—Soley.

Bancroft, Hubert Howe, 1832- History of Texas and the north Mexican states. San Francisco, History co., 1890. 2 v. maps. 24cm. "Authorities": v. 1, p. XIX-XLVIII.

Bancroft, Hubert Howe, 1832- History of the north Mexican states . . . San Francisco, A. L. Bancroft & co., 1884- . 2 v. maps. 24cm. ("Works" of H. H. Bancroft, v. XV-XVI.)

"Authorities": v. 1, p. XIX-XLVIII.

According to W. A. Morris, in Quarterly of the Oregon historical society, v. 4, p. 287-364, these volumes were the work of H. L. Oak, J. J. Peatfield, and Wm. Nemos.

Bancroft, Hubert Howe, 1832- History of the Pacific states of North America. San Francisco, A. L. Bancroft & co., 1882-90. 34 v. front. (v. 34: port.) illus., 12 maps (part fold.) fold. plan. 24cm.

A "list of authorities consulted" at the beginning of each division.

Vol. 3, 9, 11-12, 17-21, 24-27, 29-34 pub. by The History co.

With changed title-pages and binder's titles, includes the same material as his Works, San Francisco, 1882-90, 39 v.; omitting v. 1-5, The native races of the Pacific states . . .

Contents.—v. 1-3. Central America. 1882-87.—v. 4-9. Mexico. 1883-88.—v. 10. North Mexican states. 1883.—v. 11. Texas. 1889.—v. 12. Arizona and New Mexico. 1888.—v. 13-19. California. 1884-90.—v. 20. Nevada, Colorado and Wyoming. 1890. —v. 21. Utah. 1889.—v. 22-23. The northwest coast. 1884.—v. 24-25. Oregon. 1886-88.—v. 26. Washington, Idaho, and Montana. 1890.—v. 27. British Columbia. 1887.—v. 28. Alaska. 1886.—[v. 29] California pastoral. 1888.—[v. 30] California inter pocula. 1888.—v. 31-32. Popular tribunals. 1887.—v. 33, Essays and miscellany. 1890.—v. 34. Literary industries. 1890.

" . . . v. 5 being really a history of the conquest [of Cal., 1846-48], is the most abundant source, based on the largest knowledge, with a full statement in notes of all authorities, American and Mexican, essential, and even non-essential, including a large amount of manuscript material. The official documents relating to the Conquest of the northern Mexican states and Alta California, which of course are the basis, will be found grouped in the lists prefixed to the first volume of each state; and particularly see California, v. 5, p. 233, 241. . . .

. . . "[Among this manscript material] are the papers of consul T. O. Larkin, (cf. Bancroft, California, v. 1, p. 59) who was also in the beginning the secret agent of the U. S. to effect the transfer of the government of California by peaceful means, whose efforts, it seems apparent, were thwarted by the precipitate conduct of Stockton and Frémont. There has been a good deal of mystery about the exact terms of his instructions from the government, but the Larkin papers revealed the despatch, which is corroborated by the copy at Washington," . . . Winsor, v. vii, p. 444.

. . . "Both Bancroft and Royce, the latest writers, and possessing the amplest means of judging, make Larkin the main instrument of the conquest."—Soley.

1-23109 E13 .B21

Bancroft, Hubert Howe, 1832- How California was secured. (In Magazine of American history, . . . N. Y., 1887. 24cm. v. xviii, Aug., 1887, p. [194]-202.

Facsimile of author: p. 202.

"This is an abridged statement from his volume on California."—Soley.

[3-22493] in E171 .M181 v. 18

Bancroft, Hubert Howe, 1832- . . . North Mexican states . . . San Francisco, A. L. Bancroft & co., 1883-89. 2 v. illus.

(maps) 24½ cm. (History of the Pacific states of North America. By Hubert Howe Bancroft. vol. x-xi.)

Title of v. 2 reads: . . . Texas, vol. ii—1801-1889. San Francisco, The History co., 1889.

These volumes were written by H. L. Oak, J. J. Peatfield, and Wm. Nemos, according to W. A. Morris. cf. Quarterly of the Oregon hist. society, vol. 4, p. 287-364.

Also pub. as vol. 15 and 16 of Bancroft's ''Works.''

''Authorities quoted'': vol. i, p. xix-xlviii.

Contents.—v. 1. 1531-1800.—v. 2. Texas. 1801-1889.

1-23108 F851 .B22 F386 .B21

Bancroft, Hubert Howe, 1832- A popular history of the Mexican people. San Francisco, The History co., 1887. vii, 632 p. incl. illus., port., maps. 21cm.

''An abstract of the larger work, possessing almost none of the qualities which give some value to those volumes, [of the larger work]—Soley.

2-4901 F1226 .B22

Fortier, Alcee, 1856- . . . Central America and Mexico, by Alcée Fortier and John Rose Ficklen. Phila., Printed for subscribers only by G. Barrie & sons [c1907] XXVIII, 536 p. col. front., plates (partly col.) prts., maps (partly double) plan, facsims. (partly double) 23cm. (Half title: The history of North America; Francis Newton Thorpe, ed.) [v. 9]) Series title also at head of t.-p.

''This edition, printed on Japan vellum paper, is limited to one thousand numbered and registered sets.'' This copy is not numbered.

7-29849 E45 .H67

Hittell, John Shertzer, 1825-1901. A history of the city of San Francisco and incidentally of the state of California. San Francisco, A. L. Bancroft & co., 1878. 498 p. 23cm.

. . . takes the better developed views [on the conquest of Cal.]. —Soley.

Rc-675 F869 .S3H7

Kelsey, Raynor Wickersham. . . . The United States consulate in California . . . Berkeley, Cal., University of California,

1910. 107 p. 24cm. (Publications of the Academy of Pacific coast history. v. I, no. 5)

Thesis (Ph. D.)—Univ. of California. Chiefly the activities of T. O. Larkin.

Contents.—i. Historical and biographical background, p. 1-10. ii. Chronological sketch of the consulate, p. 11-16. iii. Aid to United States maritime interests, p. 17-26. iv. Safeguarding the civil rights of Americans, p. 27-34. v. Miscellaneous activities, p. 35-43. vi. Larkin's early attitude toward the acquisition, p. 44-58. vii. The confidential agency, p. 59-75. viii. Larkin's activities in the conquest of California, July, 1846-Jan. 1847, p. 75-86. Appendix. 1. Biographical sketch of Thomas O. Larkin, p. 87-93.—2. Consular representatives of France, Great Britain, and Spain in California during the Larkin consulate, p. 94-95.—3. The affair at Hawks' Peak, p. 96-99.—4. The secret despatch of October 17, 1845, p. 100-103.—5. Bibliography, p. 104-107.

. . . "Bancroft obtained the Larkin manuscripts from Sampsom Tams, living (1909) in San Francisco, husband of Caroline Larkin [1821-1891], a daughter of Thomas O. Larkin."

10-15190 F851 .A15 v. 1

Noll, Arthur Howard, 1855- From empire to republic; the story of the struggle for constitutional government in Mexico. Chicago, A. C. McClurg & co., 1903. x, 336 p. front., map. 21cm.

Appendices: A. Chronological summary of principal events related to Mexican history.—B. Bibliography.—C. Notes on the historical geography of Mexico.

3-27979 F1226 .N78 A. W. C.

Perigny, Maurice, comte **de.** . . . Les États-Unis du Mexique; préface de M. Marcel Dubois . . . Paris, E. Guilmoto, [1912] 3 p. l., [IX]-XI, 310 p. fold. map. 23cm.

13-15946 F1208 .P45

Ponce de Leon, Gregorio. El interinato presidencial de 1911, obra escrita . . . por el licenciado Gregorio Ponce de León, sobre la tarea que realizo el Señor licenciado Don Francisco León de la Barra, como presidente interino de la republica. Ed bajo los auspicios de la Secretaria de fomento, colonización, industria y comercio. Mexico, Impr. de la Secretaria de fomento, 1912. 290 p. 1 l. port. 23cm.

13-9469 F1234 .B26

Ramirez, Jose Fernando, 1804-1871. . . . Mexico durante su guerra con los Estados-Unidos. Mexico, Vda. de C. Bouret, 1905. viii, 322 p. 21cm. (Documentos inéditos ó muy raros para la historia de México, pub. por Genaro Garcia y Carlos Pereyra. t. iii)

. . . "From a previously unpublished collection of the author's letters and other papers, preserved in the Secretaria de instrucción publica y bellas artes of Mexico."

6-36140 E404 .R17

Rives, George Lockhart, 1849- The United States and Mexico, 1821-1848; a history of the relations between the two countries from the independence of Mexico to the close of the war with the United States. N. Y., C. Scribner's sons, 1913.

2 v. maps (2 fold.) plans (1 double) 24cm.

Contents.—**v. 1.** The Florida treaty, p. 1-26.—Mexico achieves her independence, p. 27-50.—The people of Mexico, p. 51-102.—The northern frontier of Mexico, p. 103-127.—The permanent settlement of Texas, p. 128-154.—Mexican politics: 1824-1830, p. 155-181.—Mexico resolves to take order with the Mexicans, p. 182-204.—Santa Anna in control, p. 205-233.—Pres. Jackson's offers to purchase Texas, p. 234-261.—Texas in arms, p. 262-285.—Texas stands by the constitution, p. 286-310.—The Mexican invasion, p. 311-337.—San Jacinto, p. 338-361.—American sympathy with Texas, p. 362-388.—Texas proposes annexation, p. 389-416.—Claims against Mexico, p. 417-444.—Santa Anna once more, p. 445-463.—The republic of Texas, p. 464-494.—The Whigs and Mexico, p. 495-524.—Efforts at mediation, p. 525-554.—British proposals for abolishing slavery in Texas, p. 555-584.—Tyler's treaty of annexation, p. 585-617.—The election of Polk, p. 618-650.—The banishment of Santa Anna, p. 651-678.—Congress invites Texas to enter the Union, p. 679-701.—Texas enters the Union, p. 703-720.—**v. 2.** The Oregon question, p. 1-21.—The problems of California, p. 22-52.—Slidell's mission, p. 53-80.—Mexico seeks foreign aid, p. 81-104.—Peace or war? p. 105-127.—Palo Alto and Resaca de la Palma, p. 128-163.—The occupation of California, p. 164-194.—Planning a campaign. The occupation of New Mexico, p. 195-220.—Santa Anna returns from exile. The Wilmot proviso, p. 220-246.—Monterey, p. 247-275.—A plan of campaign developed, p. 276-307. — Anti-clericalism and anti-slavery, p. 308-336.—Buena Vista, p. 337-367.—Chihuahua and Vera Cruz, p. 368-390.—Cerro Gordo, p. 391-417.—Scott at Puebla, p. 418-447.—Contreras, p. 448-475.—Churubusco, p. 476-499.—A futile armistice, p. 500-525.—The Molino del Rey and Chapultepec, p. 526-553.—The capture of the city of Mexico. Final military operations, p. 554-583.—The treaty of Guadalupe Hidalgo, p. 584-613.—The treaty ratified by the U. S., p. 614-637.—The conclusion of peace, p. 638-660.—List of books referred to, p. 661-674.—Index, p. 675-726.

Maps. **v. 1.** The Sabine River, p. 10.—The San Jacinto campaign, p. 346.—The kingdom of Spain at end of v. 1.—**v. 2.** The Oregon country, p. 6.—Upper California, p. 36.—Matamoras to Point Isabel, p. 150.—The battle of Monterey, p. 262.—Buena Vista, p. 352.—The battle of the Sacramento River, p. 372.—Cerro Gordo, p. 396.—Vera Cruz to the city of Mexico, p. 414.—The Valley of Mexico, p. 454.—Contreras and Churubusco, p. 460.—Chapultepec and the gates of Mexico, p. 540.—The Mexican boundary from Texas to California at end of v. 2.

A judicious and comprehensive narration of the relations of the United States with Mexico, commencing with the Florida treaty of 1819 and ending with the peace of 1848. In his political-military account, Mr. Rives has kept the slave question in its relation to expansion well in the background; he shows also a full appreciation of the Mexican's point of view. References to a wide range of printed sources and public documents in English, French and Spanish, and a good index are special features.

13-20399 F1232 .R62 A. W. C.

Soule, Frank. The annals of San Francisco; containing a summary of the history of . . . California, and a complete history of . . . its great city; to which are added, biographical memoirs of some prominent citizens. By Frank Soulé, John H. Gihon, M. D., and James Nisbet. Illustrated with 150 fine engravings . . . N. Y. [etc.] D. Appleton & co., 1855. 824 p. front., illus., plates, ports., fold. map. 24cm.

Rc-687 F869 .S3S7

Wright, Mrs. **Marie (Robinson)** 1866- Mexico, a history of its progress and development in one hundred years. Philadelphia, G. Barrie & sons; [etc., etc. c 1911] 511 p. incl. illus., plates. front. (port.) 31cm.

12-21586 F1208 .W94

Young, Philip. History of Mexico: her civil wars, and colonial and revolutionary annals: from the period of the Spanish conquest, 1520, to the present time, 1847: including an account of the war with the United States . . . by Philip Young, M. D. . . . Continued to the treaty of peace, 1848, by George C. Furber . . . Cincinnati, J. A. & U. P. James, 1850. 656 p. incl. pl. fold. map. 23 cm.

The continuation by G. C. Furber has special t.-p.: History of Mexico: continued from the capture of Vera Cruz.

2-4924 F1226 .Y69

B.

General Histories of the Mexican War, 1846-48, including also Studies of the War from a Political Standpoint

[**Alcaraz, Ramon**], ed. Apuntes para la historia de guerra entre México y los Estados-Unidos. México, Tip. de M. Payno (hijo) 1848. v p., 1 l., 401, [3] p. ports., fold. plans, fold. tables. 25cm.

"Redactores": Ramón Alcaraz, Alejo Barreiro, José Maria Castillo, Félix Maria Escalante, José Maria Iglesias, Manuel Muñoz, Ramón Ortiz, Manuel Payno, Guillermo Prieto, Ignacio Ramirez, Napoleón Saborio, Francisco Schiafino, Francisco Segura, Pablo Maria Torrescano, Francisco Urquidi.

cf. Note under next title.

5-23338 E404 .A33

[**Alcaraz, Ramon**] ed. The other side: or, Notes for the history of the war between Mexico and the United States. Written in Mexico. Tr. from the Spanish, and ed., with notes, by Albert C. Ramsey . . . N. Y., and Lond., J. Wiley, 1850. xv, [1], 458 p. front., 9 port., 14 plans. 19cm

A translation of "Apuntes para la historia de la guerra entre México y los Estados-Unidos," México, 1848.

" . . . Possesses great interest" . . . Holabird.

"Reproduces the battle-plans of the original. Best source on the conduct of the war.—" . . . Apparently a collection of notes on the war, written by fifteen Mexicans . . . gives their side of the causes . . . , describes their conduct of the campaigns, tells of sufferings of soldiers, and closes abruptly with the peace. The criticism of Gen. Santa Anna is rather severe. The translator served as colonel in the American army.—Larned.

"The Mexican side of the conquest of Cal., and New Mexico is presented in a condensed way, . . . in chap. 26.—Soley.

2-15526 E404 .34 A. W. C. W. D.

[**Allen, G. N.**] Mexican treacheries and cruelties. Incidents and sufferings in the Mexican war; with accounts of hardships endured; treacheries of the Mexicans; battles fought, and success of American arms; also, an account of valiant soldiers fallen, and the particulars of the death and funeral services in honor of Capt. George Lincoln, of Worcester. By a volunteer returned from the war. Bost., and New York, 1848. Cover-title [32] p. illus. 23cm.

2-15446 E415 .A42

The **American** gift book; or, Military souvenir . . . N. Y., Appleton; Phila., G. S. Appleton, 1848. 262 p. front., pl., port. 20cm.

Incidents in the Mexican war. Was reprinted the same year under the title: The rough and ready annual; or military souvenir.

2-15533 E404 .A51

Ampudia, Pedro de. El ciudadano general Pedro de Ampudia ante el tribunal respetable de la opinion publica, por los primeros sucesos ocurridos en la guerra à que nos provoca, decreta y sostiene el gobierno de los Estados-Unidos de América. San Luis Potosi, Impr. de gobierno en palacio, á cargo de Ventura Carrillo, 1846. Cover-title [3]-27 p. 22cm. Signed: Pedro de Ampudia.

4-4293 E411 .A52

Balbontin, Manuel. La invasion americana. 1846 á 1848. Apuntes del subteniente de artilleria M. Balbontin. México, Tip. de G. A. Esteva, 1883. 137 p. 1 l. 4 fold. maps. 22cm.

7-38063 E411 .B17

Battles of Mexico; containing an authentic account of all the battles fought in that republic from the commencement of the war until the capture of the city of Mexico: with a list of the killed and wounded. N. Y. [Martin & Ely], 1847. 98 p. illus., pl. 25cm.

The "list of the killed and wounded" is omitted [in this copy]. Copyrighted by E. Hutchinson.

2-15519 E409 .B32

Baylies, Francis, 1783-1852. The march of the United States troops, under the command of General John E. Wool, from San Antonio, Texas, to Saltillo, Mexico, in the year 1846. By Hon. F. Baylies. Original communication. (In Strykers' American register and magazine. Washington [etc., etc.], 1850. 24cm. v. 4, p. 297-312.)

''Names of officers, as far as ascertained, who accompanied Gen. Wool's column, and were in the great battle of Buena Vista . . . . . . p. 310-312.''

[5-32095] in AP2 .S92 v. 4

Bellemare, Louis i. e. **Eugene Louis Gabriel de,** 1809-1852. (Gabriel Ferry, pseud.) La guerre des États-Unis et du Mexique. (In Revue des deux mondes. Paris, 1847. 23cm. 17e année. Nouvelle série. Tome 19 [v. 3], août, 1847, p. 385-431.)

[11-16662-5] AP20 .R3, 1847.

[**Benton, Thomas Hart**], 1782 1858. Thirty years' view; or, A history of the working of the American government for thirty years, from 1820 to 1850. Chiefly taken from the Congress debates, the private papers of General Jackson, and the speeches of ex-Senator Benton, with his actual view of men and affairs: with historical notes and illustrations and some notices of eminent deceased contemporaries: by a senator of thirty years . . . N. Y., D. Appleton & co.; Bost., F. Parker, 1854-56. 2 v. fronts. (v. 1: port.) 24cm.

War with Mexico. See v. 2, Administration of James K. Polk, p. 639-736.

7-8611 E338 .B47 E. S.

Brackenridge, Henry Marie. Mexican letters written during the progress of the late war between the United States and Mexico, by H. M. Brackenridge: now collected and republished, with notes and corrections, to be completed in two numbers . . . [no. I] Wash., printed by R. A. Waters, 1850. 85 p. 23cm.

Author's autograph signature at end of preface.

2-17191 E407 .B79

Brooks, Nathan Covington, 1819-1889. A complete history of the Mexican war: its causes, conduct, and consequences: comprising an account of the various military and naval operations, from its commencement to the treaty of peace. Phila., Griggs, Elliot & co.; Baltimore, Hutchinson & Seebold, 1849. XVI [5]-558 p. incl. front. 11 pl., 22 port., 2 maps, 11 plans. 24cm.

2-15425 E404 .B87 W. D.

Bustamente, Carlos Maria de. El nuevo Bernal Del Castillo, ó sea, Historia de la invasión de los Anglo-Americanos en México. Escrita por el licenciado Carlos Maria de Bustamente . . . Mexico, Impr. de V. Garcia Torres, 1847. 2 v. 24cm.

Probably no more published. cf. v. 2, p. 235.

2-15429 E404 .B98

Cass, Lewis, 1782-1866. The war with Mexico. Speech of Hon. Lewis Cass, of Michigan, in the Senate of the U. S., Jan. 3, 1848. On the bill reported from the Committee on military affairs to raise, for a limited time, an additional military force. [Wash., D. C.] Congressional globe office [1848]. 8 p. 23cm. Caption title.

10-16034 E407 .C34

Complete history of the late Mexican war. Containing an authentic account of all the battles fought in that republic, including the treaty of peace: with a list of the killed and wounded. Together with a brief sketch of the lives of Generals Scott and Taylor . . . By an eye-witness. N. Y., F. J. Dow & co., 1850. 128 p. incl. front., illus. port. 23cm.

2-15423 E404 .C73

Coppee, Henry, 1821-1895. Coincidences of the conquests of Mexico, 1520-1847. By prof. Henry Coppée . . . (In Journal of the Military service institute of the U. S., N. Y., March, 1884 23cm. v. 5, no. 17, p. 29-55, incl. 1 sketch-map.)

[8-15848-9] in U1 .M6 v. 5 E. S.

Cowan, John E. comp. . . . Condensed history of the Mexican war and its glorious results, by Hon. Wm. McKay . . . also reminiscences of the war by Colonel Dan E. Hungerford . . . and Col. Chas. J. Murphy . . . Comp. and pub. by John E. Cowan . . . 1st ed., 25000. [N. Y.? 1902?] 41 p. 3 port. (incl. front.). 23cm.

Errata slip attached to frontispiece.

4-23284 E404 .C87

Duflot de Mofras, Eugene, b. 1810. Expéditions des Espagnols êt des Américains au Mexique en 1829 et en 1847. Paris, Typ. E. Panckoucke & cie., 1862. 39 p. 21cm.

"Extrait du Moniteur universel des 11 et 12 octobre 1862."

8-20785 E404 .D85

French, Samuel Gibbs. Two wars: an autobiography of Gen. Sam. G. French . . . Mexican war; war between the States, a diary; reconstruction period, his experience; incidents, reminiscences, etc. Nashville, Tenn., Confederate veteran, 1901. XV [1], 404 p. incl. illus., port. front. (port.) 24cm.

1-27326 E467.1 .F87T9

Frost, John, 1800-1859. The Mexican war and its warriors; comprising a complete history of all the operations of the American armies in Mexico: with biographical sketches and anecdotes of the most distinguished officers in the regular army and volunteer force. New Haven and Phila., H. Mansfield, 1850. 6 [VII]-VIII, 9-332, 11 [1], p. incl. col. front., illus., plates, ports., map. pl. 20cm.

13-18442 E405 .F93

Frost, John, 1800-1859. Pictorial history of Mexico and the Mexican war: comprising an account of the ancient Aztec empire, the conquest by Cortes, Mexico under the Spaniards, the Mexican revolution, the republic, the Texan war, and the recent war with the United States. Embellished with . . . engravings from designs of W. Croome and other distinguished artists. Phila., Thomas Cowperthwait and co., for J. A. Bill, 1848. XII [13]-640 p. incl. illus., port., plans. col. front., 6 col. pl. 24cm.

2-15426 E404 .F93

Gallatin, Albert, i. e., **Abraham Albert Alphonse,** 1761-1849. Peace with Mexico. N. Y., Bartlett & Welford [1847] cover-title [3]-34 p. 23cm.

Republished 1848, in Waterman pamphlets, v. 45, no. 6 [etc., etc.].

7-23556 7-23555 E407 .G168 E407 .G169 W. D.

George, Isaac. Heroes and incidents of the Mexican war, containing Doniphan's expedition, the cause of the war with Mexico, a description of the people and customs at that time, a sketch of the life of Doniphan, together with sketches and portraits of the heroes of that struggle. N. Y., Review pub. co., 1903.

Green, James Stephen, 1817-1870. The war with Mexico. Speech of Hon. J. S. Green, of Missouri, in the House of representatives, Jan. 25, 1848. In Committee of the whole on the state of the Union, on the resolutions referring the President's message to the various standing committees. [Wash., D. C.] Printed at the Congressional globe office [1848]. 7 p. 23 cm. Caption title.

10-16038 E407 .G79

Grone, Carl von, d. 1849. Briefe über Nord-Amerika und Mexiko und den swischen beiden geführten krieg, von Carl von Grone. Nach dessen tode herausgegeben und mit einem vorworte begleitet von A. C. E. von Grone. Braunschweig, Druck von G. Westermann; N. Y., G. & B. Westermann bros., 1850. VIII p., 1 l., 110 p. 23cm.

3-32102 E411 .G87

Halleck, Henry Wager, 1815-1872. Elements of military art and science. . . . 3d ed. N. Y., Lond., D. Appleton & co., 1863. 449 p. plans, diagrs. 20cm.

Appendix, p. [409]—et seq., contains critical notes on the Mexican war.

War 9-150 A. W. C. E. S.

Hamilton, John, 1823-1900. History of the Mexican war by Gen. C. M. Wilcox . . . [A review]. (In Journal of the U. S. artillery, Fort Monroe, Va., 1892. 22cm. v. 1, p. 291-299; v. 2, p. 141-144.) cf. Lane, W. B.

[6-13361] in UF1 .J86 v. 1; 2 E. S.

Hardie, Francis Hunter, 1854- The Mexican war. By Capt. F. H. Hardie, 3d U. S. Cavalry. (In Journal of the Military service institution of the U. S. Nov., 1894. 23cm. v. 15, no. 72, p. 1203-1211.)

[8-15848] in U1 .M6 v. 15 E. S.

Henry, Wm. Seaton, 1816-1851. Campaign sketches of the war with Mexico. By Capt. W. S. Henry. N. Y., Harper & bros., 1847. V [7]-331 p. incl. illus., pl., front., plans. 20cm.

2-15597 E404 .H52 A. W. C.

History of Texas. By a traveller. (In Colburn's united service magazine, . . . Lond., 1847. 23cm. pt. 1, p. 70-80; 516-527.)

"Battle of San Jacinto." Copy of original document written by

Gen. Houston in 1836, p. 80. Mexican war, 1846-48, p. 524-527.

[6-5657] in U1. U6 v. 1847, pt. 1 E. S.

History of the war between the U. S. and Mexico. From the best authorities. Phila., G. B. Zieber & co., 1847. 168 p. incl. illus., 9 pl., port. 23cm.

2-15532 E404 .H67

Jay, Wm., 1789-1858. A review of the causes and consequences of the Mexican war. 2d ed. Bost., B. B. Mussey & co.; Phila., U. Hunt & co.; [etc., etc.]. 1849. 333 p. 20cm.

Written from the Abolitionist point of view . . . . He wrote in a spirited, cutting style, and used the best of English. The story of the Mexican war from this side has never been better told, or more forcibly and logically argued.—Larned.

2-15555 E404 .J42

Jenkins, John Stilwell, 1818-1852. History of the war between U. S. and Mexico, from the commencement of hostilities to the ratification of the treaty of peace. Auburn [N. Y.], Derby, Miller & co., 1849. xiv [15]-514 p. front., pl., port. 23cm.

Another ed. issued ibid., 1851.—A translation of extracts from this book into French was pub. in Paris, cf. next title.
" . . . a politician's affair."—Soley.

2-15530 E404 .J53 A. W. C. W. D.

Jenkins, John Stilwell, 1818-1852. Extrait de l'histoire de la guerre entre les Etats-Unis et le Mexique en 1847. Traduit de l'Anglais et complété d'après les documents officiels publiés par le gouvernement américain par le chef d'escadron d'état-major Jouve. Dépôt de la guerre. [Paris] Bosc [1862?] 101 p. 34cm. Lithographed from manuscript.

2-137 E404 .J57

Johnson, Herschel Vespasian, 1812-1880. The war with Mexico. Speech of Hon. H. V. Johnson, of Georgia, in the Senate of the U. S., March 16, 1848, on the bill reported from the Committee on military affairs to raise, for a limited time, an additional military force. [Wash., D. C., Printed at the Congressional globe office, 1848.] 16 p. 25cm. Caption title.

10-16046 E407 .J67

Ladd, Horatio Oliver, 1839- . . . History of the war with Mexico. N. Y., Dodd, Mead & co. [1883]. 4 [v]-xii, [13]-328 p. front., 3 fold. pl., fold. map. 19cm. (Minor wars of the U. S.)

. . . "Convenient little history, giving a fairly good general view," . . .—Soley.

"Ought to be welcomed by a great many persons who have wished a compendious account . . . The illustrations are for the most part of the usual kind—fancy pictures—but good of their kind."—Nation, 1883.

2-15554 E404 .L15 A. W. C.

Lane, Wm. Bartlett. History of the Mexican war, by Gen. C. M. Wilcox [a review], by Major W. B. Lane. (In Journal of the U. S. artillery, Ft. Monroe, Va. 1892. 22cm. v. 1, p. 412-421.)

A reply to a review by Col. John Hamilton, q. v.

[6-13361] In UF1 .J86 v. 1 E. S.

Livermore, Abiel Abbot, 1811-1892. The war with Mexico reviewed. Bost., American peace society, 1850. XII, 310 (i. e., 298) p. 20cm.

Paging irregular: p. 298 numbered 310. . . . To this work was awarded the five hundred dollar prize offered by the Am. peace society "for the best review of the Mexican war on the principles of Christianity, and an enlightened statesmanship."

. . . Describes the expenditures, inhumanities, vices of camps, military executions, and all the horrors of war. . . . Soley. . . . "is of very little consequence save as it presents in very strong light some of the causes of the war. The value of the book is in chapters 3-8, where is clearly presented, from extracts of writings and speeches, the desire of the South to acquire new territory in the interests of slavery."—C. K. Adams.

2-15444 E415 .L77

[**McPherson, John D.**] The evolution of the myth, as exemplified in Gen. Grant's history of the plot of President Polk and Secretary Marcy to sacrifice two American armies in the Mexican war of 1846-48. By Senex. Wash., D. C., W. H. Morrison, 1890. 54 p. 19cm.

2-15471 E407 .M17

Mansfield, Edward Deering, 1801-1880. The Mexican war: a history of its origin, and a detailed account of the victories which terminated in the surrender of the capital; with the official despatches of the generals. N. Y., Barnes & co.; Cincinnati, Derby, Bradley & co., 1848. IV [5]-323 p., incl. maps, plans., front., pl. 20cm.

. . . In large part composed of official documents; and its narrative is in effect abridged in his Life of Scott. . . . Santa Anna's account is translated in p. 143-162.—Soley.

Also published in 1849, 1873, etc.

2-15550 E404 .M28 A. W. C.

Mayer, Brantz, 1809-1879. History of the war between Mexico and the United States, with a preliminary view of its origin. N. Y., Lond., Wiley and Putnam, 1848. 188 p. front. (port.) 2 plans. 22cm.

Several other editions.

. . . "not without rendering justice to the Mexican arms."—Soley.

2-15553 E404 .M46

Moody, Loring. A history of the Mexican war, or Facts for the people, showing the relation of the United States government to slavery. Compiled from official and authentic documents. 2d ed., with additions and corrections. Bost., B. Marsh, 1848. XI [12]-120 p. 19cm.

Also pub., Boston, 1847, under title: Facts for the people.

"Showing relations of the U. S. government to slavery."—Soley.

2-15399 E404 .M81

Murphy, Chas. J., 1832- Reminiscences of the war of the rebellion, and of the Mexican war. N. Y., F. J. Ficker, 1882. cover-title, 80 p. 23cm.

10-29587 E601 .M97

Paz, Eduardo. La invación norte americana en 1846; ensayo fe historia patria-militar por el mayor de caballeria Eduardo Paz. Mexico, C. Paz, 1889. 3 p. l., 44 p. 1 fold. tab. 18½cm.

2-25082 E404 .P35

Peterson, Chas. Jacobs, 1819-1887. The military heroes of the war with Mexico: with a narrative of the war. Phila., W. A. Leary, 1848. 282 p. incl. illus., port. front., pl., port. 24cm. [With his: Military heroes of the war of 1812. Phila., 1848.]

. . . a specimen of the ready-made book of the hour.—Soley.

2-17595 E353 .P48

Porter, Chas. T. Review of the Mexican war, embracing the causes of the war, the responsibility of its commencement, the purposes of the American government in its prosecution, its benefits and its evils. Auburn, N. Y., Alden & Parsons, 1849. VII [8]-220 p. 19cm.

2-15443 E415 .P84

Read, Benj. Maurice, 1853- Guerra mexico-americana . . . [Por] Benjamin M. Read . . . Santa Fé, N. M., Compania impresora del Nuevo Mexicano, 1910. 259 p. front. (port.) facsims. 23cm.

10-15827 E407 .R28

Riley, Roswell Sabine. The war with Mexico. N. Y., Harper & bros., 1849. 2 v. 14 plans. 23cm.

. . . On the American side, the best military history. . . . Deals fully with strategic operations, and, except for a certain tendency to underrate the work of the navy, it is a highly satisfactory book. It was not altogether satisfactory, however, to some of his brother officers, and issue was taken with him in certain directions by Isaac J. Stevens, in his ''Campaigns'' . . . q. v.—Soley.

A rather pretentious history of the Mexican war—now out of print . . . probably the best work that we have on the subject.—Brevt. Brig. Gen. Holabird.

2-15449 E404 .R59 A. W. C. W. D.

Roa Barcena, Jose Maria. Recuerdos de la invasion norte-americana, 1846-1848, por un joven de entónces. Obra de Don José Maria Bárcena . . . Mexico, J. Buxó y ca., 1883. 3 p. l., II 686 p. 24cm.

Bancroft (in his: History of Mexico) states, v. 5, p. 433, in a footnote, that this is the result of study of both American and Mexican documents . . .

His style is clear and elegant; his conclusions impartial as may be expected.—Soley.

2-21294 E404 .R62

Robarts, William Hugh. Mexican war veterans. A complete roster of the regular and volunteer troops in the war between the United States and Mexico, from 1846 to 1848 . . . Comp. from official sources by Wm. H. Robarts . . . Wash., D. C., Brentano's, 1887. 80 p. 23cm.

2-15454 E409 .R62

Robinson, Fayette, d. 1859. An account of the organization of the army of the United States; with biographies of distinguished officers of all grades. By F. Robinson. Phila., E. H. Butler & co., 1848. 2v. front., port. 19cm.

. . . Of more special character with sketches of leading generals. —Soley.

v. 1. Corps of engineers, p. 60-80. Sappers, miners, and pontoniers, p. 83. War with Mexico, p. 255-282. Gaines, p. 285-330.

v. 2. Taylor, p. 5-92. Wool, p. 93-116. Twiggs, p. 117-128. Kearny, p. 129-148. Gen. Worth, p. 226-330.

Portraits, v. 1: Gen. Scott (front.); Gen. Brown, p. 26; Maj. Barbour, p. 65; Cols. Thayer, p. 70; Totten, p. 75; Gens. Macomb, 106; Towson, p. 169; Commodore Conner, p. 262; Col. Hitchcock, p. 266; President Santa Anna, p. 274; Gens. Persifor F. Smith, p. 279; Gaines, p. 285; Gibson, p. 313; Arbuckle, p. 315; Clinch, p. 322; Brooke, p. 326.

v. 2: General Taylor (front.); Col. Cross, p. 25; Capt. Walker, p. 31; Lieut. Blake, p. 45; Maj. McCall, p. 40; Col. May, p. 48; Don Mariano Arista, p. 56; Col. Childs, p. 61; Gens. Wool, p. 93; Twiggs, p. 117; Kearny, p. 129; Col. Fremont, p. 145; Majors Boone, p. 159; Ringgold, p. 177; Col. Bankhead, p. 182; Gen. Jones, p. 191; Cols. Payne, p. 197; Croghan, p. 208; Gen. Worth, p. 226; Don Mariano Paredes, p. 330.

''. . . they [the portraits] have been made from undoubted authorities, the majority after daguerreotypes by Mr. Clarke (late Anthony Edwards & co.), of New York, and Mr. Root, of Philadelphia. A few . . . from pencil sketches by distinguished artists and officers of the army. . . . engravings . . . by Messrs. Croome and Brightly . . . ''

2-7174 E181 .R65

Santa Anna, Antonio Lopez de, pres. Mexico, 1795-1876. . . . Las guerras de Mexico con Tejas y los Estados Unidos. Mexico, Vda. de C. Bouret, 1910. 344 p. 21cm.

(Documentos inéditos ó muy raros para la historia de Mexico, pub. por Genaro Garcia. t. XXIX.)

Contents.—I. Manifiesto que de sus operaciones en la campaña de Tejas y en su cautiverio dirige á sus conciudadanos el general Antonio López de Santa Anna. 10 de mayo de 1837.—II. Manifiesto del general de división, benemérito de la patria, Antonio López de Santa Anna, á sus conciudadanos. 24 de marzo de 1848.—III. Impugnación al informe del Exmo. Sr. general D. Antonio López de Santa Anna y constancias en que se apoyan las ampliaciones de la acusación del Sr. diputado D. Ramón Gamboa. 15 de julio de 1849.

10-14167 E401 .S23 A. W. C.

Sevier, Ambrose Hundley, 1801-1848. The war with Mexico. Speech of Hon. A. H. Sevier, of Arkansas, in the Senate of the U. S., Jan. 4, 1848, on the bill reported from the Committee on military affairs to raise, for a limited time, an additional military force. [Wash., D. C.] Printed at the Congressional globe office [1848]. 15 p. 25cm. Caption title.

10-15741 E407 .S51

Shackford, Chas. Chauncy. A citizen's appeal in regard to the war with Mexico. A lecture, delivered at Lyceum Hall, Lynn, Jan. 16, 1848, by Charles C. Shackford. Bost., Printed by Andrews & Prentiss, 1848. 40 p. 23cm.

2-15456 E407 .S52

A **short** statement of the causes which led to the war with Mexico: showing the inconsistent course of the Whig party on the subject. [Washington, 1848.] 8 p. 24cm.

A pamphlet containing the president's message, May 11, 1846, etc. Caption title.

2-15518 E407 .S55

Steele, Matthew Forney, 1861- See U. S. General staff. Second section. American campaigns.

Stevens, Isaac Ingalls, 1818-1862. Campaigns of the Rio Grande and of Mexico. With notices of the recent work of Major Ripley. By Bvt.-Major Isaac I. Stevens, U. S. army. N. Y., D. Appleton and co., 1851. 108 p. 23½cm.

cf. Note under Ripley, R. S. The war with Mexico.

Author served as Adjutant of engineers in the siege of Vera Cruz, March 9-29, 1847.—Was in battle of Cerro Gordo, April 17-18, 1847; Reconnaissance of the Peñon, Aug. 12-13, 1847, and of San Antonio, Aug. 18, 1847; in battle of Contreras, Aug. 19-20, 1847; Reconnaissance and battle of Churubusco, Aug. 20, 1847. (Was made Bvt. Capt., Aug. 20, 1847, for gallant and meritorious conduct in the battles of Contreras and Churubusco, Mex.) In battle of Molino del Rey, Sept. 8, 1847; on reconnaissance of the southern approaches to the city of Mexico, Sept. 9-13, 1847; in battle of Chapultepec (Bvt. Major, Sept. 13, 1847, for gallant and meritorious conduct in the latter battle), Sept. 13, 1847, and in assault and capture of the city of Mexico, Sept. 13-14, 1847, where he was wounded in the San Cosme suburb.

2-15433 E404 .S84 A. W. C.

[**Tuttle, I. F.**] Our late conquest [in the Mexican war]. (In The New Englander. New Haven, 1848. 23cm. v. 6, p. 524-534.)

[1-2990] in AP2 .N5 v. 6

U. S. Adjutant-general's office. . . . Military forces employed in the Mexican war. Letter from the Secretary of war, transmitting information in answer to a resolution of the House, of July 31, 1848, relative to the military forces employed in the late war with Mexico. [Washington, 1850.] 34 p. 9 fold. tables. 25cm. ([U. S.] 31st Cong., 1st sess. House. Ex. doc. 24.)

8-20777 E409 .U55

U. S. Adjutant-general's office. . . . Regulars and volunteers engaged in the Mexican war. Letter from the Secretary of war transmitting a report from the Adjutant general . . . in relation to the number of United States troops that have been engaged in the war with Mexico, the number who have been killed, died from wounds, &c. [Washington, 1848.] 86 p. 24½cm. ([U. S.] 30th Cong., 1st sess. House. Ex. doc. no. 62.)

5-10327 E409 .U56

[**U. S.** Congress. Committee on Foreign affairs.] War with Mexico. June 24, 1846. Mr. C. J. Ingersoll, from the Committee on Foreign affairs, made the following report, ... [Wash., D. C., 1846.] 52 p. 24cm. ([U. S.] 29th Cong., 1st sess. House. Report no. 752. Serial 491.)

n. t.-p.

[Report on reasons for] "The act of Congress, approved May 13, 1846, for the prosecution of the existing war between the United States and Mexico, having become a law, . . . the President's special message . . . . . . was pretermitted." . . .

Cong. doc. Serial 491.

U. S. General staff. Second section. . . . American campaigns, by Matthew Forney Steele. . . . Wash., B. S. Adams, 1909. VIII p., 1 l., 731 p. and atlas of XII p., 311 maps (part col.) 24cm. (Its [Publications] no. 13.)

"These volumes represent a part of my three years' work as lecturer in military history at the Army service schools at Fort Leavenworth. . . .''—Author's pref.

Mexican war.—Taylor's campaign, lecture V, p. 81-104.—Scott's campaign, lecture VI, p. 105-126.

Maps (in v. 2) : Theatre of operations, 48.—Part of Texas and northern Mexico, 49.—Country northeast of Matamoros, 50.—Battle of Palo Alto, 51.— . . . Resaca de la Palma, 52.— . . . of Monterey, 53.—Monterey and Saltillo, 54.—Battle of Buena Vista, 55.—Siege of Vera Cruz, 56.—Vera Cruz to Mexico, 57.—Battle of Cerro Gordo, 58.—Valley of Mexico, 59.—Operations of the American army in the valley of Mexico, 60.—Battle of Contreras, 61.— . . . of Churubusco, 62.— . . . of El Molino del Rey, 63.—Chapultepec, 64; 65; 66.

War 9-114 E181 .U61 E. S.

[**U. S.**] President, 1845-49 (Polk). Message of the President of the United States, communicating information of the existing relations between the United States and Mexico, and recommending the adoption of measures for repelling the invasion committed by the Mexican forces upon the territory of the United States. May 11, 1846. Read, and ordered to be printed; and that 20,000 copies, in addition to the usual number be printed, together with so much of the President's annual message as relates to the Mexican affairs, for the use of the Senate . . . [Wash., D. C., 1846.] 337 p. 24cm. ([U. S.] 29th Cong., 1st sess. Senate. Ex. doc. 337. Serial 476.)

''List of papers,'' p. 7.

''Message of President communicating further information of the proceedings of the United States troops, May 13, 1846, on the Rio del Norte,'' p. [126]-131.

Cong. doc. Serial 476.

[**U. S.**] President, 1845-49 (Polk). Message from the President of the United States to the two Houses of Congress at the commencement of the 2d session of the 29th Congress. Dec. 8, 1846 . . . Wash., D. C., Printed by Ritchie & Heiss, 1846. 109 p. 24cm. ([U. S.] 29th Cong., 2d sess. Senate Doc. 1. Serial 493.)

List of papers from the Department of state accompanying the President's message, p. 34.

General Santa Anna's ''plan,'' p. 35-36.—General Anna's letter and note, March 8 and April 8, 1846, p. 36-39.—Reports of Generals Taylor and Wool, Sept. 22, 1846, p. 76-109.

''The company of Engineer soldiers, or sappers, miners, and pontoniers.'' [Report], by Jos. G. Totten, Colonel and Chief engineer, p. 137. Cong. doc. Serial 493.

U. S. President, 1845-1849 (Polk). . . . Message from the President of the United States to the two houses of Congress, at the commencement of the first session of the Thirtieth Congress . . . Wash., D. C., Printed by Wendell and Van Neythuyden [!], 1848. 1369, 249 p. fold. maps, fold. tab. 23cm. ([U. S.] 30th Cong., 1st sess. Senate. Ex. [doc.] 1. Serial no. 503.)

''Dec. 7, 1847. Read, and ordered that 25,000 copies of the message, and 2,000 copies of the message with the accompanying documents, in addition to the usual number, be printed for the use of the Senate.''

The message (p. [3]-35) is accompanied by reports of the secretaries of state, war and navy and the postmaster-general.

''Appendix. Report of the Secretary of war, in answer to a resolution of the Senate. Calling for such military reports as have been received from the commanders of our army in Mexico, since the transmission of the annual report of the Secretary of war:'' 249 p. at end.

Contents (selected).—Landing of army at Vera Cruz, March 9, 1847, p. 216.—Vera Cruz, March 17, 1847, p. 220.—Col. Totten and his assistants commended, p. 220.—''Norther'' delays work of engineers on battery no. 4, p. 225.—Gen. Scott refers to services of Col. Totten, p. 230.—Col. Totten appointed one of commissioners to treat of surrender of Vera Cruz, p. 232.—Gen. Scott mentions Col. Totten in general orders no. 80, p. 239.—Gen. Scott mentions Engineer officers, p. 240.—Efficient services rendered by officers; Col. Totten commends on services of engineers to Gen. Scott, p. 244-245.—Engineers and Topographical engineers with Gen. Patterson.—Capt. Hardee disembarking horses, p. 251.—Lieut. Derby, Topographical engineers wounded; Lieut. Johnston wounded, p. 256.—Report of Chief of Engineers, Nov. 18, 1847 [signed] Jos. G. Totten, Colonel and Chief Engineer, p. 594.—Regarding officers of engineers and the Company of engineer soldiers, p. 626.—Report of Col. J. J. Abert, of Topographical engineers, p. 656.—Appendix.—Engineers at battle of Contreras, p. 66.—Engineers at battle of Churubusco, p. 69.—Brevt. Col. B. Riley commending Tower, p. 90.—Capt. J. B. Magruder commends Foster and McClellan, p. 104.—Lieut. Gustave W. Smith reports operations of engineers in attacking city of Mexico, p. 167.—Lieut. Beauregard reports attack on Chapultepec, Sept. 12, 1847, p. 190.

Maps.—Plan of battle of Buena Vista, Feb. 22-23, 1847. Surveyed by Capt. Linnard and Lieuts. Pope and Franklin, Corps of engineers. Drawn by Capt. T. B. Linnard, Corps of Topographical engineers. Scale, 1,000 ft. to one inch, p. 136.—Survey of the Mexican lines of defence at Cerro Gordo, and lines of attack of the American army under Maj. Gen. Scott, . . . April 17, 18, 1847. Surveyed by Maj. Turnbull and Capt. McClellan, Topographical engineers. Drawn by Lieut. H. Coppée, p. 256.—Map of the Valley of Mexico. By Edmund L. F. Hardcastle, Bvt. 2d Lieut. Topographical engineers, also, Profile of route between Mexico and Vera Cruz, p. 300.—Battles of Mexico. Line of operations of the U. S. army under command of Maj. Gen. W. Scott, Aug. 19-20, 1847. Surveyed by Maj. Turnbull, Capt. McClellan, and Lieut. Hardcastle, Corps of Top. engineers. Drawn by Hardcastle, p. 300.—Map of Gen. Worth's operations, Aug. 20, 1847.—Surveyed by Capt. Mason, of engineers, and Lieut. Hardcastle, Top. engineers, p. 312.—Sketch of the operations of the 1st Division, U. S. army under command of Gen. Worth, Sept. 8, 1847, by E. L. F. Hardcastle, Bvt. 2d Lieut., Top. engineers, p. 364.—Battle of El Molino del Rey, p. 364.—Plan accompanying Gen. Quitman's report, showing fall of Chapultepec, p. 408.—Sketch of the battle of Sacramento, Feb. 28, 1847, p. 504.—Sketch of actions fought at San Pascal in Upper Cal., between the American and Mexicans, Dec. 6-7, 1846, p. 512.—Sketch of the battle de Los Angeles, Upper Cal., fought between Americans and Mexicans, Jan. 9, 1847. From a sketch of Emory, p. 524.—Sketch of the passage of the Rio San Gabriel, Upper Cal., by the Americans, discomfiting the opposing Mexican forces, Jan. 8, 1847, from sketch by Lieut. Emory, p. 524.—Distances and number of men. Fort Sacramento to San Diego . . . the Mormon Battalion not included . . . June 19, 1847, p. 524.—Sketch accompanying Col. Price's despatch of April 18, 1847, and that of Feb. 15, 1847, p. 524.—Sketch accompanying Col. Price's despatch of Feb. 15, 1847 (Battle of Puebla de Taos), p. 524.

8-33611 E404 .U57 E. S.

U. S. President, 1845-1849 (Polk) . . . Message from the President . . . (The same as preceding title.) 1275 p. fold. maps, fold. plans, fold. tables. 25cm. ([U. S.] 30th Cong., 2d sess. House. Ex. doc. 1.)

''Dec. 5, 1848. Read, and committed to the Committee of the whole house on the state of the Union, and 15,000 extra copies, with the accompanying documents, ordered to be printed.''

The message (p. [3]-44) is accompanied by reports of the secretaries of state, treasury, war and navy and the postmaster-general.

. . . Contains in the first 500 pages a detailed military history of the Mexican war, except the opening operations of 1846. The

President's message and the report of the Secretary of war are accompanied by the reports of the officers in the field covering the military operations from the battle of Buena Vista to the capture of the city of Mexico. An appendix of 249 pages supplies further military reports, chiefly from subordinate officers, received too late to accompany the report of the Secretary of war. The volume includes much matter not relating to the war, and the indices to the military material must be looked for on p. 541 of the main document, and p. 234 of the appendix.

Reports and despatches exhibiting the operations of the U. S. Naval forces during the war with Mexico, p. [1005]-et seq.

No. 52 Operations of the Pacific squadron. Correspondence relating to the civil government in California and New Mexico, p. 47-50.—List of documents accompanying the report of the Secretary of War, p. 85.

8-33609 E404 .U58

U. S. President, 1845-1849 (Polk) . . . Occupation of Mexican territory. Message from the President of the United States transmitting in answer to a resolution of the House of representatives of Dec. 15, 1846, reports from the Secretary of war and the Secretary of the navy relative to the occupation of Mexican territory. Wash., D. C., Govt. print. off., 1912. 76 p. 23cm. ([U. S.] 62d Cong., 2d sess. Senate. Doc. 896.)

Formerly pub. as House Executive doc. 60 ([U. S.]) 30th Cong., 1st sess. (p. 149-299, inclusive.)

12-40005 F800 .U58 A. W. C.

[**U. S.** President (1845-49) Polk.] Refusal to furnish instructions to Mr. Slidell. Message from the President of the United States, transmitting documents in relation to the return of Santa Anna and Paredes to Mexico, and refusing to furnish the instructions given to Mr. Slidell, as requested by the resolution of the House of Representatives of the 4th Jan., 1848. Read, and made the special order of the day for Tuesday next. [Wash., 1848], 29 p. 24cm. ([U. S.] 30th Cong., 1st sess. House Ex. doc. 25. Serial 516.)

no title-page.

Cong. doc. Serial 516.

[**U. S.** State dept.] Correspondence between the Secretary of War and Generals Scott and Taylor, and between General Scott and Mr. Trist. Message from the President of the United States, transmitting Reports from the Secretary of

State and Secretary of War, with accompanying documents, in compliance with the resolution of the House of Representatives, of the 7th Feb., 1848. March 20, 1848. Laid upon the table, and ordered to be printed. [Wash., D. C., 1848] [406], ix [x] p. 24cm. ([U. S.] 30th Cong., 1st sess. House. Ex. doc. 56. Serial 518.)

no title page. At end: Index to documents . . . Cong. doc. Serial 518.

[**U. S.** State dept.] Hostilities by Mexico. Message from the President of the United States, relative to an invasion and commencement of hostilities by Mexico. May 11, 1846. Read, and referred to the Committee of the Whole House on the state of the Union. [Wash., D. C., 1846.] 120 p. 24cm. ([U. S.] 29th Cong., 1st sess. House. Ex. doc. 196. Serial 485.)

no title-page.

Cong. doc. Serial 485.

[**U. S.** State dept.] The treaty between the United States and Mexico, the proceedings of the Senate thereon, and message of the President and documents communicated therewith; the messages, with correspondence between the Executive department, General Scott and Mr. Trist and other papers and proceedings of the Senate in relation thereto, from which the injunction of secrecy has been removed. In executive session, Senate of the United States, Wednesday, May 31, 1848. . . . June 2, 1848. [Wash., D. C., 1848.] 384 p. 24cm. ([U. S.] 30th Cong., 1st sess. Senate. Ex. doc. 52. Serial 509.)

no title-page.

Cong. doc. Serial 509.

Contents.—Senate executive proceedings on and text of treaty of Guadalupe Hidalgo, p. 1-67.—Message of Pres. Polk of Feb. 23, 1848, communicating the treaty to the Senate for consideration before ratification; and Buchanan, Slidell, Trist correspondence, Nov. 10, 1845, to Nov. 27, 1847, p. 69-103.—(This correspondence is also reproduced in 30th Cong., 1st sess., Senate Ex. doc. 60. Serial 509, p. 33-66.)—Letter from Mr. Trist, Feb. 12, 1848, relative to maps connected with the treaty, p. 104-105.—Message of Pres. Polk transmitting correspondence (Buchanan, Trist, Walker) relative to terms of authority given Mr. Trist to draw 3000000 dollars; April 15, 1847, to Feb. 23, 1848, p. 106-109. —Confidential message of Pres. Polk communicating correspondence between Mr. Trist and the Mexican commissioners, between Mr. Trist and the Secretary of State, in relation to negotiation with the Mexican commissioners, all the correspondence between Gen. Scott and the government and between Gen. Scott and Mr. Trist; Jan. 14, to Dec. 29, 1847, p. 110-306.—Correspondence between the Supreme Government of Mexico and the General-in-Chief of the American army and the Commissioner of the U. S., p. 307-348.—The same, in Spanish: Contestaciones habidas entre el Supremo Gobierno Mexicano, el General-en-Gefe del ejército americano, y el comisionado de los Estados Unidos, p. 349-384.—(First printed in Mexico in 1847, as a pamphlet of 36 pages, with the title here given.)

[**U. S.** State dept.] Treaty with Mexico. Message of the President of the United States, transmitting a copy of the treaty of peace, friendship, limits, and settlement, between the United States and the republic of Mexico, ratifications of which were exchanged at the city of Queretaro, in Mexico, on the 30th of May, 1848. July 22, 1848. Ordered to be printed. [Wash., D. C., 1848.] 74 p. 24cm. ([U. S.] 30th Cong., 1st sess. House. Ex. doc. 69. Serial 521.)

no title-page.

Cong. doc. Serial 521.

[**U. S.** War dept.] Correspondence between the Secretary of War and General Scott. Message from the President, transmitting the correspondence between the Secretary of War and Major-General Scott, with the accompanying documents, in compliance with the resolution of the House of Representatives of the 17th instant. April 26, 1848. Laid upon the table, and ordered to be printed. [Wash., 1848.] 63 p. 24cm. ([U. S.] 30th Cong., 1st sess. House. Ex. doc. 59. Serial 518.)

n. t.-p.

Cong. doc. Serial 518.

[**U. S.** War dept.] Correspondence with General Taylor since the commencement of hostilities with Mexico. March 1, 1847. Read, and laid upon the table. [Wash., D. C.] Ritchie & Heiss, prtrs. [1847] 454 p. 24cm. ([U. S.] 29th Cong., 2d sess. House. Ex. doc. 119. Serial 500.)

Covers the period from May 13, 1846, to Feb. 18, 1847, and is continued in House Ex. doc. 17, 30th Cong., 1st sess. Serial 516, q. v.

Cong. doc. Serial 500.

[**U. S.** War dept.] Correspondence with General Taylor. Message from the President of the United States, transmitting a report of the Secretary of war and accompanying documents, in answer to a resolution of the House of Representatives of the 1st of Feb., 1847, being in addition to his report made on the 27th of the same month. Jan. 4, 1848. Read, and laid upon the table. [Wash., 1848.] 30 p. 1 l. 24cm. ([U. S.] 30th Cong., 1st sess. House. Ex. doc. 17. Serial 516.)

n. t.-p. At end: ''Index to papers. Capture of Monterey.''

Report of Bvt. Maj. Jos. K. Mansfield, Engineers, dated Oct. 9, 1846, to Maj. Gen. Taylor, p. 2-4. cf. 29th C. 2d sess. House. Ex. doc. 119. Serial 500.

Cong. doc. Serial 516.

[**U. S.** War dept.] Despatches from General Taylor. Message from the President of the United States, transmitting Despatches from General Taylor, relative to Colonel Cross, and missing lieutenants.—General Taylor ordered by the Mexican general to leave his position on the Rio Grande.—Blockade, &c. May 12, 1846. Read, and laid upon the table. [Wash., D. C., 1846.] 6 p. 24cm. ([U. S.] 29th Cong., 1st sess. House. Ex. doc. 197. Serial 485.)

n. t.-p.

Cong. doc. Serial 485.

[**U. S.** War dept.] Letter from the Secretary of War, communicating a supplemental report of the battle of Cerro Gordo, made by General Pillow to General Scott. March 24, 1852. Ordered to lie on the table and be printed. [Wash., D. C., 1852.] 4 p. 24cm. ([U. S.] 32d Cong., 1st sess. Senate. Ex. doc. 51. Serial 619.)

n. t.-p.

Signed: C. M. Conrad, Secretary of War.—G. J. Pillow, Brig. General.

Cong. doc. Serial 619.

[**U. S.** War dept.] Message from the President of the United States communicating a copy of the treaty with the Mexican republic, of Feb. 2, 1848, and of the correspondence in relation thereto, and recommending measures for carrying the same into effect. July 6, 1848. Read, and ordered to be printed, and that 5000 additional copies be printed . . . [Wash., 1848.] 74 p. 24cm. ([U. S.] 30th Cong., 1st sess. Senate. Ex. doc. 60. Serial 509.)

n. t.-p.

Cong. doc. Serial 509.

President Polk's message of July 6, 1848, on laying before Congress the ratified treaty; text of treaty and Buchanan, Slidell, Trist, Clifford and Sevier correspondence; Nov. 10, 1845, to June 12, 1848. The Buchanan, Slidell, Trist correspondence (Nov. 10, 1845, to Nov. 27, 1847) is reprinted from U. S. 30th Cong., 1st sess. Senate. Ex. doc. 52, p. 71 et seq.

[**U. S.** War dept.] Message from the President of the United States, communicating a report from the Secretary of War, in answer to a resolution of Senate calling for copies of the letters, reports, or other communications referred to in General Taylor's letter, dated at New Orleans, July 20, 1845, as containing his views as to the line proper to be occupied at that time by the United States troops; and any similar communication from any officer of the army on the subject. Jan. 31, 1848. Read, and ordered to be printed. [Wash., 1848.] 9 p. 24cm. ([U. S.] 30th Cong., 1st sess. Senate. Ex. comm. no. 18. Serial 506.)

n. t.-p. Includes correspondence between Gen. Taylor and the War dept. from June 18 to July 30, 1845.

Cong. doc. Serial 506.

[**U. S.** War dept.] Message from the President of the United States, communicating a report from the Secretary of War, with information in relation to forced contributions in Mexico, called for by a resolution of the Senate Jan. 24, 1848. Read, and ordered to lie on the table, and to be printed. [Wash., 1848.] 24 p. 24cm. ([U. S.] 30th Cong., 1st sess. Senate. Ex. doc. 14. Serial 506.)

n. t.-p.

Contains correspondence between Generals Taylor, Wool and Scott, covering the period from Sept. 22, 1846, to Dec. 14, 1847. The document concludes with extracts from the Mexican financial report of 1845, submitted by Gen. Scott with the remark, "a paper from which I expect to derive many valuable suggestions in levying the means in Mexico for the support of the occupation.'' p. 13.

Cong. doc. Serial 506.

[**U. S.** War dept.] Message from the President, communicating a report from the Secretary of War, in answer to a resolution of the Senate calling for information in relation to General order no. 376, issued by General Scott. Jan. 31, 1848. Read, and ordered to be printed. [Wash., 1848.] 4 p. 24cm. ([U. S.] 30th Cong., 1st sess. Senate. Ex. doc. 19. Serial 506.)

n. t.-p. Contains text of General order 376, issued by Gen. Scott on Dec. 15, 1847. The order relates to the levying of duties.

Cong. doc. Serial 506.

[**U. S.** War dept.] Messages of the President of the United States, and correspondence, therewith communicated, between the Secretary of War and other officers of the government upon the subject of the Mexican war. April 28, 1848. ... Wash., Wendell & Van Benthuysen, ptrs., 1848. 1277 p. 24cm. ([U. S.] 30th Cong., 1st sess. House. Ex. doc. 60. Serial 520.)

At head of caption-title: Mexican war correspondence.

''Hostilities by Mexico. Message from President, relative to an invasion and commencement of hostilities by Mexico,'' p. 4 et seq.

Letters and dispatches of the Secretary of the Navy, Commodore Sloat, Connor [!], Biddle, and Stockton, p. 231-271.

Correspondence with General Taylor, p. 272-273; 281 et seq.

''Synopsis of correspondence'': p. 274-280.

This is a compilation of all correspondence . . . relating to the Mexican war. Cong. doc. Serial 520.

U. S. War dept. . . . Military contributions in Mexico. Message of the President of the United States, transmitting reports from the secretaries of war and navy, in answer to a resolution of the House of the 20th Dec. last, relative to the money and property received at the various Mexican ports during the late war, &c. [Wash., D. C., 1849.] 120 p. 25cm. ([U. S.] 30th Cong., 2d sess. House. Ex. doc. 47.) Caption title.

''January 31, 1849. Referred to the Select committee on the subject of military contributions in Mexico, and ordered to be printed.''

8-34287 E404.U61 Cong. doc. Serial 541

[**U. S.** War dept.] Official despatches from General Taylor. Message from the President of the United States, transmitting copies of all the official despatches received from General Taylor, commanding the Army of occupation on the Rio Grande, in compliance with a resolution of the House of Representatives of the 27th instant. May 27, 1846. Read, and referred to the Committee on military affairs. [Wash., D. C., 1846.] 7 p. 24cm. ([U. S.]) 29th Cong., 1st sess. House. Ex. doc. 207. Serial 485.)

n. t.-p.

Cong. doc. Serial 485.

[**U. S.** War dept.] Publication of the ''Gaines letter.'' Message from the President of the United States, transmitting a copy of General Taylor's answer, to the letter dated Jan. 27, 1847, addressed to him by the Secretary of War. Feb. 4, 1848. Laid upon the table, and ordered to be printed. [Wash., 1848.] 3 p. ([U. S.] 30th Cong., 1st sess. House. Ex. doc. 37. Serial 516.)

n. t.-p.

Cong. doc. Serial 516.

U. S. War dept. . . . Report of the Secretary of war, in answer to a resolution of the Senate, calling for such military reports as have been received from the commanders of our army in Mexico, since the transmission of the annual report of the secretary of war . . . (In: U. S. President, 1845-1849 (Polk) Message from the President . . . at the commencement of the first session of the 30th Congress. Wash., 1848. 23cm. 249 p. at end.)

''Jan. 4, 1848.—Ordered to be printed with the annual report of the secretary of war.''

8-33610 E404.U57 E409.U57

[**U. S.** War dept.] Report of the Secretary of War, in further compliance with the resolution of the Senate of Aug. 3, 1848, calling for a map of the Valley of Mexico, by Lieutenants Smith and Hardcastle. Jan. 29, 1849. Ordered to be printed. [Wash., D. C., 1848.] 19 p. 24cm. ([U. S.] 30th Cong., 2d sess. Senate. Ex. doc. 19. Serial 529.)

n. t.-p. cf. 31st Cong., 1st sess. Senate. Ex. doc. 11. Serial 554.

Cong. doc. Serial 529.

[**U. S.** War dept.] Report of the Secretary of War communicating, in compliance with a resolution of the Senate, a map of the Valley of Mexico, from surveys by Lieutenants Smith and Hardcastle. Jan. 19, 1849. Referred to Committee on military affairs. Jan. 29, 1849.—Report in favor of lithographing the map. Jan. 3, 1850.—Referred to Committee on military affairs. Jan. 10, 1850.—Report in favor of engraving the map and printing the memoir made and concurred in; 2500 copies in addition to usual number to be printed, 500 of which are for the Topographical bureau. [Wash., D. C., 1850.] 13 p. 1 fold. map. 24cm. ([U. S.] 31st Cong., 1st sess. Senate. Ex. doc. 11. Serial 554.)

n. t.-p. cf. 30th Cong., 2d sess. Senate. Ex. doc. 19. Serial 529.

Cong. doc. Serial 554.

Lieut. Martin Luther Smith, 1819-1866. Made 1st Lieut., 1853, capt., 1856. Resigned April 1, 1861, entered the Confederate army, and rose to the rank of brig.-general, at head of the Engineer corps. Commanded a brigade in defense of New Orleans, and planned and constructed the defenses of Vicksburg, where he was taken prisoner. Subsequently he became Maj.-General. From National cyclopaedia of American biography, . . . N. Y., J. T. White & co., 1907. 30cm. v. 5, p. 96 (with port.)

Lieut. Edmund La Fayette Hardcastle, 1824-1899. Cadet, 1842; 1. July (3); Bvt. 1st Lieut., Aug. 20, 1847, for gallant . . . conduct in the battle of Contreras and Churubusco; and capt., Sept. 8, 1847, for gallant . . . in battle of Moline del Rey. Died, Aug., 1899.

[**U. S.** War dept.] Report of the Secretary of War, communicating, in compliance with a resolution of the Senate, information of the number and description of troops from Alabama mustered into the service of the United States since the 1st of April, 1846. July 1, 1846. Read, and ordered to be printed. [Wash., D. C., 1846.] 2 p. 24cm. ([U. S.] 29th Cong., 1st sess. Senate. Ex. doc. 415. Serial 477.)

n. t.-p.

Cong. doc. Serial 477.

[**U. S.** War dept.] Report of the Secretary of War showing the names of the officers and men killed, wounded, or missing, in the battles of Palo Alto and Resaca de la Palma, Dec. 10, 1846. Ordered to lie on the table, and to be printed. [Wash., D. C., 1846.] 78 p. 24cm. ([U. S.] 29th Cong., 2d sess. Senate. Doc. 4. Serial 494.)

n. t.-p.

Cong. doc. Serial 494.

The **war** and its warriors; comprising a history of all the operations of the American armies in Mexico: with biographical sketches and anecdotes of the most distinguished officers in the regular army and the volunteer force. Philadelphia, Hogan & Thompson, 1848. 319 p. incl. front., illus., pl., port. 19cm.

2-15551 E404.W25

Wheeler, Junius Brutus, 1830-1886. A course of instruction in the elements of the art and science of war. . . . N. Y., D. Van Nostrand, 1878. xiv [5]-326 p. illus. 19cm.

"General order no. 111, issued by Scott at Plan del Rio, April 17, 1847, the evening before his attack on the Mexican army under Santa Clara, in position on the heights of Cerro Gordo, in 1847." . . . p. 150-152.

12-40231 U102.W56 E.S.

Wilcox, Cadmus Marcellus, 1826-1890. History of the Mexican war. By General C. M. Wilcox. Ed. by his niece, Mary Rachel Wilcox. Wash., D. C., Church news pub. co., 1892. x, 711 p. front., pl., port., plans. 23cm.

Appendices: A. Treaty of Guadalupe Hidalgo.—B. The court of inquiry.—C. Roster of army officers serving in Mexico.—D. Roster of volunteer officers serving in Mexico.—E. Roster of navy officers serving in Mexico.—F. Names of the original members of the Aztec club. . . . 1847.

"An intensive study of the military operations of the war from an expert standpoint. The writer served as a 2d Lieut., and a portion of the description is from personal observation. The book is likely to prove heavy for the non-military reader. The appendix contains among other matters a roster of all the troops in the service. [Signed:] E. E. S. (Edwin Erle Sparks, prof. American history, Univ. of Chicago).—Larned.

cf. Review of the book by J. H. (In Military service institution of the U. S. Journal, v. 14, no. 61, Jan., 1893, p. 198-200.)

2-15548 E404.W66 E.S. A.W.C.

Willard, Mrs. Emma (Hart), 1797-1870. Last leaves of American history; comprising a separate history of California. By Emma Willard . . . N. Y., A. S. Barnes & co.; Cincinnati, W. H. Derby & co., 1853. 277 p. front. (map). 19cm.

"The account of the Mexican war, herein contained, is taken from the author's history of 'The republic of America.'"—Preface.

2-15440 E404.W70

Zirckel, Otto. Tagebuch geschrieben während der nordamerikanisch-mexikanischen campagne in den jahren 1847 und 1848 auf beiden operationslinien. Halle, H. W. Schmidt, 1849. 2 p. l., 179 p. 22cm.

2-15447 E411.Z81

B.—a

The Mexican War, 1846-48: Works Relating to the Conquest of California and New Mexico

Colton, Walter, 1797-1851. Three years in California [1846-1849]. By Rev. Walter Colton, U. S. N. . . . N. Y., Barnes & co.; Cincinnati, H. W. Derby & co., 1850. 456 p. front., plates, ports., map, fold. facsim. 19cm.

Facsimile: ''Declaration of rights in the Constitution of California, and the signatures of the members of the Convention.'' The book was republished by the same firms, 1851. 456 p. 6 pl., 6 port. (incl. front.) fold. facsim. 19cm.

Gives an excellent notion of some aspects of the [Mexican] war. He was made Alcade of Monterey by Stockton.—Soley.

Rc-774 F865.C7

The **conquest** of Santa Fé and subjugation of New Mexico, by the military forces of the U. S.; with documents, embracing the opinions of the Honourable Thomas H. Benton, Gen. Sam. Houston, and others, in reference to annexation; and a history of Colonel Doniphan's campaign in Chihuahua. By a captain of volunteers. Phila., H. Packer & co., 1847. 3, 7-48 p. 24cm.

7-9653 E405.2.C75

Cooke, Philip St. George, 1809-1895. The conquest of New Mexico and California; an historical and personal narrative. N. Y., G. P. Putnam's sons, 1878. iv p. 1 l., 307 p fold. map. 19cm.

Personal experiences relating to the conquest of the Northern Mexican states and Alta California. . . . covers the infantry march to the Pacific, and the final stages of the conquest there . . .—Soley. ''Gen. Cooke describes many interesting events in which he took part as a young lieut.-colonel in 1846-47, commanding the so-called Mormon Battalion of 500 dragoons. He opposed Frémont's course in California, and criticises him severely. It is surprising that a volume published more than thirty years after the journey should still perpetuate so many crude and erroneous observations . . . desultory book . . .—Larned.

2-15557 E405.2.C77 A.W.C. W.D.

Cooke, Philip St. George, 1809 1895. Report . . . of his march from Santa Fé, New Mexico, to San Diego . . . California. (In U. S. Engineer dept. Notes of a military reconnaissance . . . [With reports . . .] Wash., D. C., 1848. 24cm. p. [549-563]. ([U. S.] 30th Cong., 1st sess. [House]. Ex. doc. no. 41.

Rc-84 F786.U571 W.D.

Cutts, James Madison. The conquest of California and New Mexico, by the forces of the U. S., in the years 1846 & 1847. Phila., Carey & Hart, 1847. 1 p. l., 264 p. front. (port.) maps, plans. 19cm. Added t.-p., engr., with port. of J. C. Frémont. Front. is port. of Brig.-Gen. Kearny.

Consists chiefly of official dispatches.—Soley.

2-15556 E405.2.C98

Hughes, John Taylor, 1817-1862. Doniphan's expedition; containing an account of the conquest of New Mexico; Gen. Kearney's [!] overland expedition to California; Doniphan's campaign against the Navajos; his unparalleled march upon Chihuahua and Durango; and the operations of Gen. Price at Santa Fé: with a sketch of the life of Col. Doniphan. Cincinnati, J. A. & U. P. James, 1848. viii, 9-144 p. incl. front., illus., plans. 24cm.

2-15474 E405.2.H87 W.D.

Another ed., ibid., 1850. xii, 13-407 p. front., illus., port., fold. map, plans. 20cm.

2-15476 E405.2.H89 W.D.

A conscientious portrayal of the events attending the expedition of the "Army of the West" during the Mexican war of 1846-47, including the conquest of New Mexico, the treaty with the Navaho Indians, and Doniphan's remarkable invasion and capture of Chihuahua and his triumphant march through Durango and Coahuila with less than 100 men. Capt. Hughes was "an eye-witness of, and an actor in," many of the scenes which he essays to describe. His account of Kearny's march from New Mexico to California is compiled from other but authentic sources, . . . [Signed] : F. W. H.—Larned.

. . . Is the essential review of the whole matter. He had the advice of the leading officers and his own experience.—Soley.

Hughes, John Taylor, 1817-1862. . . . Doniphan's expedition and the conquest of New Mexico and California. By Wm. Elsey Connelley . . . Includes a reprint of the work of Col. John T. Hughes. Topeka, Kan. The author, 1907. xiv p., 1 l., 670 p. front., illus., ports., maps (2 fold.) 23½cm.

At head of title: War with Mexico, 1846-1847.

A reprint, with extensive additions, of John T. Hughes' "Doniphan's expedition," first published in Cincinnati in 1848. Includes photographic reproduction of title-page of original edition.

"Col. Alexander W. Doniphan—his life and character. By D. C. Allen": p. 15-39.

"Diary of Col. John T. Hughes [August 17, 1846, to May 13, 1847]": p. 59-111.

"Personal recollections of Charles R. Morehead": p. 601-622.

7-26431 405.2H9

Jones, Wm. Carey, 1855- The first phase of the conquest of California. In California historical society. Papers. San Francisco, 1887. 27cm. v. 1, pt. 1, p. [61]-94.

Larkin, Thomas Oliver, 1802-1858. The Larkin papers. (Manuscripts.) 1909. Fully listed in Kelsey, R. W. The U. S. Consulate in Cal. Appendix 5, p. [104]-107. (In Academy of Pacific coast history. Berkeley. Publications. 1910, no. 5.)

These papers are now in possession of the Library of the University of California.

McWhorter, George Cumming. Incident in the war of the U. S. with Mexico, illustrating the services of Wm. Maxwell Wood, surgeon U. S. N. in effecting the acquisition of California. By Geo. Cumming McWhorter, esq. Read before the New York historical society. [New York?] Sherwood & co.'s steam press [187-?] cover-title, 9 [1] p. 20cm.

2-18684 E405.2.M17 W.D.

Revere, Joseph Warren, 1812-1880. A tour of duty in California; including a description of the gold region: and an account of the voyage around Cape Horn; with notices of Lower California, the Gulf and Pacific coasts, and the principal events attending the conquest of the Californias. By Jos. W. Revere . . . Ed. by Jos. N. Balestier . . . With a map and plates from original designs. N. Y., C. S. Francis & co.; Bost., J. H. Francis, 1849. 3 p. l., [iii]-vi p., 1 l., 305 p. front., plates, fold. map. 20cm.

. . . is a gossipy and discursive book, but contains much original testimony, of a useful character, as to Stockton's operations, Revere being a lieutenant in his squadron, and taking an active part in the events of the campaign.—Soley.

Rc813 F865.R4

Royce, Josiah, 1855- . . . California, from the conquest in 1846 to the Second vigilance committee in San Francisco [1856]; a study of American character, by J. Royce . . . Bost., and N. Y., Houghton, Mifflin and co., 1886. xv, 513 p. front. (map). 18cm. Half-title: American commonwealths.) Series title also at head of t.-p.

. . . The author made use of the material in the Bancroft library, and submitted his proofs to General Frémont.—Soley.

Rc-815 F865.R88

Twitchell, Ralph Emerson. The history of the military occupation of the territory of New Mexico from 1846 to 1851 by the government of the United States, together with biographical sketches of men prominent in the conduct of the government during that period, by R. E. Twitchell . . . Denver, Colo., The Smith-Brooks co., 1909. 394 p. incl. illus., pl., ports., maps, facsims. 23cm.

Biographical sketches: p. 203-394.

9-19863 F801.T97 A.W.C.

[**U. S.** State dept.] New Mexico and California. Message of the President of the United States, transmitting in answer to resolutions of the House of Representatives of July 10, 1848, reports from the Secretaries of State, Treasury, War, and Navy. July 24, 1848. Ordered to be printed [Wash., D. C., 1848.] 49 p. 24cm. ([U. S.] 30th Cong., 1st sess. House. Ex. doc. 69. Serial 521.)

n. t.-p.

Cong. doc. Serial 521.

Wislizenus, Adolphus, i. e., Frederick Adolphus. . . . Memoir of a tour to northern Mexico, connected with Col. Doniphan's expedition, in 1846 and 1847. By A. Wislizenus, M. D. (With a scientific appendix and three maps.) . . . Wash., Tippin & Streeper, printers, 1848. 141 p. fold. pl., 2 fold. maps. 24cm. ([U. S.] 30th Cong., 1st sess. Senate. Misc. 26. Serial 511.)

2-4815 F1213.W81

A German translation was published under title: Denkschrift über eine reise nach Nord-Mexico, verbunden mit der expedition des obersten Donniphan, in den jahren 1846 und 1847 . . . Aus dem englischen übertragen von G. M. von Ross. Mit einem wissenschaftlichen anhange . . . Braunschweig, F. Vieweg und sohn, 1850. viii, 211 p., maps. 24cm.

2-4816 F1213.W82

U. S. Engineer dept. . . . Notes of a military reconnaissance from Fort Leavenworth, in Missouri, to San Diego, in California, including parts of the Arkansas, Del Norte, and Gila rivers. By W. H. Emory, brevet-major, Corps of topographical engineers. Made in 1846-7, with the advanced guard of the "Army of the West." Washington, Wendell and Van Benthuysen, printers, 1848. 416 p., plates. 23cm. ([U. S.] 30th Cong., 1st sess. Senate. Ex. doc. no. 7. Serial 505.)

Another edition, of same date, with fold. map (ordered printed Dec. 16, 1847) is found in the Congressional series of public documents. (Serial no. 505.)

"Sketch of the battle of Los Angeles, Upper California, fought between the Americans and Mexicans, Jan. 9, 1847," facing p. 159.—"Sketch of the actions fought at San Pasqual in Upper California, between the Americans and Mexicans, Dec. 6, 7, 1846," facing p. 142.—"Sketch of the passage of the Rio San Gabriel, Upper California, by the Americans—discomfiting the opposing Mexican forces, Jan. 8, 1847," facing p. 157.

Fold. map: "Military reconnaissance of the Arkansas, Rio del Norte and Rio Gila, by W. H. Emory, Lieut., Topographical engineers. Assisted from Fort Leavenworth to Santa Fé, by Lieuts. J. W. Abert and W. G. Peck, and from Santa Fé to San Diego, on the Pacific, by Lieut. W. H. Warner and Mr. Norman Bestor. Made in 1846-7, with the advance guard of the "Army of the West" under command of Brig. Gen. Stephen W. Kearny. Constructed under the orders of Col. J. J. Abert, Chief Corps of topographical engineers. 1847. Drawn by Joseph Welch. Scale, 17cm. to 160 miles. "The survey of the Sierra de Jumanes, the Sierra Grande, the Gran Quivira region, and the Rio Puerco and its tributaries, was made by Lieuts. Abert and Peck, of the Corps of top. engineers."

The map gives heights in feet, above the level of the sea, ranches on the right and left of the trail, wagon route from Rio

Grande to Pino Village (explored and surveyed by Lieut. Col. Cooke, being that over which he conducted his battalion and train of wagons to the Pacific), table of geographical positions, etc., etc.

5-17615 Rc-181 F786.U57 E.S. W.D.

C.

Special Campaigns and Battles.—Personal Narratives.—Regimental Histories.

Allen, Lewis Leonidas. Pencillings of scenes upon the Rio Grande; originally published bn [!] the Saint Louis American. By the Rev. L. L. Allen . . . New York, 1848. 48 p. 20cm.

2-15452 E411.A42

Anderson, Robt., 1805-1871. An artillery officer in the Mexican war, 1846-7; letters of Robert Anderson, captain 3rd artillery, U. S. A., with a prefatory word by his daughter, Eba Anderson Lawton, with 21 illus. N. Y., Lond., Putnams, 1911. xvi p., 1 l., 339 p., front., plates, ports. 23cm.

Illustrations: Gen. R. Anderson (front.)—Maj. Gen. Robt. Patterson, p. 16.—Gen. Scott, p. 46.—View of Tampico, p. 60.—Gen. Taylor, p. 66.—View of Mount Orizaba from Vera Cruz, p. 80.—Siege of Vera Cruz, p. 92.—Gen. Santa Anna, p. 106.—Gen. Worth, p. 111.—Rough sketch of battle-ground of Cerro Gordo, April 18, 1847, p. 139.—Panorama of Puebla, p. 170.—Puebla de Los Angeles, p. 176.—Mexican water carriers, p. 188.—Scene in a Mexican market, p. 204.—View of Mount Iztaccihuatl from the east, p. 242.—The pyramid of Cholula, p. 252.—Making tortillas, p. 262.—View of Popocatepetl from Puebla, p. 282.—Scene at the battle of Molino del Rey, p. 310.—Battle of Chapultepec, p. 314.—Mexico city looking southwest from the cathedral, p. 328.

11-28847 E411.A54 E.S. A.W.C.

Backus, Electus. A brief sketch of the battle of Monterey; with details of that portion of it which took place at the eastern extremity of the city. By the late Col. E. Backus, U. S. A. (In: Historical magazine, . . . Morrisana, N. Y., 1866. 18 x 24cm. v. 10, p. 207-213.)

Bancroft refers to this in his: "History of Mexico," v. V, p. 384-385.

[5-5123] in E171.H64 v. 10

Backus, Electus. Details of the controversy between the regulars and volunteers, in relation to the part taken by each in the capture of battery no. 1, and other works at the east end of the city of Monterey, on the 21st of Sept., 1846. By the late Col. E. Backus, U. S. A. (In: Historical magazine, . . . Morrisania, N. Y. 1866. 18x24cm. v. 10, p. 255-257.)

Footnote: "Like the article, from the same pen, in the July number [p. 207, q. v.] the following was communicated to me by the gallant author of it, since deceased. [Signed]: H. B. D. (H. B. Dawson).

[5-5123] E171.H64 v. 10

[**Ballentine, George**] b. 1812? The Mexican war, by an English soldier. Comprising incidents and adventures in the United States and Mexico with the American army. N. Y., W. A. Townsend & co., 1860. xii [9]-288 p. front. 20cm.

Added t.-p., engraved: Adventures of an English soldier in the United States army.

Originally published under title: Autobiography of an English soldier in the U. S. army. (In Colburn's united service magazine, . . . Lond., 1851-52. 22cm. pt. 3, 1851; pts. 1-3, 1852), then in book form. Lond., Hurst and Blackett, 1853. 2 v. 20cm. N. Y., Stringer & Townsend, 1853. xii [9]-288 p. pl. 20cm.

A narrative of Scott's campaign from the standpoint of an intelligent private soldier, which derives additional freshness and value from the fact that the author was a foreigner. Written by a clear-headed and educated man.—Soley.

4-7010 2-15451 E411.B193 E411.A93

E411.B192 in U1.U6 9-2368 6-5657

Baylies, Francis, 1783-1852. March of the United States troops under Gen. Wool from San Antonio, Texas, to Saltillo, Mexico, 1846. (In: Am. quarterly register, July, 1850.)

[5-32095] in AP2.S92 v. 4

Baylies, Francis, 1783-1852. A narrative of Major-General Wool's campaign in Mexico, in the years 1846, 1847, and 1848. Albany, Little & co., 1851. 78 p. front. (port.) 23cm.

4-37287 E405.4.B35

[**Benham, Henry Washington,** 1813-1884.] Recollections of Mexico and the battle of Buena Vista, Feb. 22 and 23, 1847. By an engineer officer, on its 24th anniversary. [Anon.] Bost.,

1871. Cover-title, 27 p. 23cm. Re-published from "Old and new," for June and July, 1871.

2-15462 E406.B9B4

Bishop, W. W. Journal of the 12 months' campaign of Gen. Shield's brigade in Mexico, 1846-47, compiled from notes of of Lieuts. J. J. Adams and H. Dunbar. By W. W. Bishop, Captain, Illinois volunteers. St. Louis, 1847.

[**Bonner, J.**] Scott's battles in Mexico. (In: Harper's new monthly magazine. N. Y., 1855. 24cm. v. xi, June-Nov., 1855, p. 311-324. Illus.)

This is an unsigned article, but in the Index to Harper's new monthly magazine . . . v. i-lxxxv., N. Y., Harper & bros., 1898, 24cm., p. 87, John Bonner is given as the author.

[4-12670] in AP2H3 v. 11

Brackett, Albert Gallatin, 1829-1896. General Lane's brigade in central Mexico. Cincinnati, H. W. Derby & co.; N. Y., J. C. Derby, 1854. ix [10]-336 p. front. (port.) 20cm.

2-15463 E405.6.B79

Brackett, Albert Gallatin, 1829-1896. History of the United States cavalry, from the formation of the federal government to the 1st of June, 1863. To which is added a list of all the cavalry regiments, with names of their commanders, which have been in the United States service since the breaking out of the rebellion. N. Y., Harper & bros., 1865. xii [13]-337 p. incl. front. pl., maps. 20cm.

Mexican war, chap. iii-vi, p. 53-125.

2-7747 E181.B78

Buhoup, Jonathan W. Narrative of the central division, or army of Chihuahua, commanded by Brig. General Wool: embracing all the occurrences . . . from the time of its rendezvous at San Antonio de Bexar till its final disbandment at Camargo —with an account of its sufferings while passing through a barren and hostile country—together with a description of the battle of Buena Vista, &c., and an interesting appendix. Pittsburgh, M. P. Morse, 1847. xii [13]-168 p. 19cm.

2-15464 E405.4.B93

The **capture** of Vera Cruz. By an eye-witness. [Anon.] (In: The Knickerbocker, or, New York monthly magazine. N.Y., 1847. 24cm. v. 30, July, 1847, p. 1-8.)

[Signed:] E. C. H.

[1-2996] in AP2.K64 v. 30

Carleton, James Henry, 1814-73. The battle of Buena Vista, with the operations of the "Army of occupation" for one month. N. Y., Harper & bros., 1848. vii, 238 p. front. (map) plan. 17cm.

Carleton was a dragoon officer in the fight. He combines personal observation with a study of the official documents, and enables the student to follow his investigations by footnotes.—Soley.

2-15461 E406.B9C2 E. S. A.W.C. W. D.

Carpenter, Wm. W. Travels and adventures in Mexico: in the course of journeys of upward of 2500 miles, performed on foot. Giving an account of the manners and customs of the people, and the agricultural and mineral resources of that country. N. Y., Harper & bros., 1851. xi [13]-300 p. 19½ cm.

Experiences of the author in the Mexican war and after his capture near Monterey in 1847.

2-4775 F1213.C29

Deas, George. Reminiscences of the campaign on the Rio Grande. By Maj. G. Deas, U. S. A. (In: Historical magazine, . . . Morrisania, N. Y., 1870. 26cm. 2d series, v. 7, p. 19-22; 99-103; 236-238; 311-316.)

Footnote: "The major did not complete his sketches; and we leave the subject where he left it." Editor, Historical magazine, p. 316.

[5-5123] in E171.H64 v. 7 W. D.

Donnavan, Corydon. Adventures in Mexico; experienced during a captivity of seven months. 12th ed. With an appendix. Bost., G. R. Holbrook & co., 1848. 132 p. front. (port.) 24cm.

7-21668 E411.D69

Edwards, Frank S. A campaign in New Mexico with Colonel Doniphan. By F. S. Edwards, a volunteer. With a map of the route, and a table of the distances traversed. Phila., Carey and Hart, 1847. xvi [17]-184 p.. map., tab. 19cm.

Another ed., Lond., 1848.

2-15465 E405.2.E26

Encarnacion prisoners: comprising an account of the march of the Kentucky cavalry from Louisville to the Rio Grande, together with an authentic history of the captivity of the American prisoners, including incidents and sketches of men and things on the route and in Mexico. By a prisoner. Louisville, Ky., Prentice and Weissinger, 1848. 96 p. 21cm.

2-15432 E412.E56

Frontier service [in the Mexican war] by an old cavalryman. [Anon.] (In: Southern magazine. Baltimore, 1874. 23cm. v. 15, p. 74-86.) [Signed:] M.

Author was a member of the regiment of "Mounted Riflemen," which was added to the permanent military establishment of the United States in spring 1840. Gen. Percifer F. Smith of Louisiana was its first colonel. Author mentions Lee on p. 71 and Capt. Claiborne on p. 85.

[5-14025] in AP2.S84 v. 15

Furber, George C. The twelve months volunteer; or, Journal of a private in the Tennessee regiment of cavalry, in the campaign in Mexico, 1846-7; comprising four general subjects: I. A soldier's life in camp; amusements; duties; hardships. II. A description of Texas and Mexico, as seen on the march. III. Manners; customs; religious ceremonies of the Mexicans. IV. The operations of all the twelve months volunteers, including a complete history of the war with Mexico . . . By G. C. Furber, of Company G. Cincinnati, J. A. & U. P. James, 1849. xi [12]-640 p., incl. illus., pl., plans., front., fold. map. 23cm.

See also Young, Philip. History of Mexico. . . .

[Furber] also wrote a continuation of Young's History of Mexico, which includes the period of the war, and offers a good share of the documentary proofs. The above book [twelve months volunteer] was republished several times.—Soley.

2-15588 E404.F98

A **general's** orderly in Mexico. (In: Colburn's united service magazine, . . . Lond., 1855. 23cm. part ii, p. 78-85.)

Personal experience of an orderly of Gen. Patterson (Mounted company of artillery).

[6-5657] in U1.U6, 1855 pt. 2 E.S.

Gibson, J. W. Letter descriptive of the battle of Buena Vista, written on the ground. Lawrensburgh, Ind., 1847.

[**Giddings, Luther.**] Sketches of the campaign in northern Mexico. In 1847. By an officer of the First regiment of Ohio volunteers. N. Y., For the author by G. P. Putnam & co., 1853. xii [13]-336 p., front. (map), plan. 21cm.

2-15448 E405.1.G45 A.W.C.

Grindall, John J. The battle of Buena Vista. [A poem.] Baltimore, Press of I. Friedenwald, 1882. 10 p. 15cm.

Originally pub. in United service review, Phila., 1881. 25cm. v. 5, p. 47-51.

Republished by the Virginia association of Mexicans, and dedicated to J. F. Milligan, vice-president of same and to all survivors of the Mexican war.

5-33368 E406.B9G9

Hartman, George W. A private's own journal: giving an account of the battles in Mexico, under Gen'l Scott, with descriptive scenes, and roll of Company ''E,'' 2nd Pa. regiment, with the age, height, occupation and residence of officers and men, also, a table of heights and distances from Vera Cruz to the city of Mexico. By G. W. Hartman, a youth who volunteered in his 19th year. Greencastle [Pa.]. Printed by E. Robinson, 1849. 35 p. 18cm.

2-15516 E411.H33

The ''**high private,**'' with a full and exciting history of the New York volunteers, illus. with facts, incidents, anecdotes, engravings, &c., &c., including the mysteries and miseries of the Mexican war. In three parts: Part first. To which will be appended the constitution and by-laws of the guerrillas, banditti, &c., found on Priest Jaurata. By ''Corporal of the guard.'' N. Y., Printed for the publishers, 1848. 60 p. illus. 20cm. Copyrighted by Albert Lombard.

Caption title: Sketches, incidents, anecdotes, mysteries and miseries of the First [!]New York volunteers, Col. Ward B. Burnett, commanding, during part of 1846-1847-1848. No more published.

The regiment commanded by Col. Burnett was the 2d regiment.

5-5559 E409.H63

Hopkins, G. T. The San Patricio battalion in the Mexican war. (In: Journal of the U. S. Cavalry association. Ft. Leavenworth, Kan., Sept., 1913. 24cm. v. 24, no. 98, p. 279-284, incl. table.)

Table: Deserters from U. S. army, 1846, who joined the Mexican army, and who formed the St. Patrick Company, . . .

Foot-note: ''These notes have been furnished by Capt. Frank McCoy, General Staff, U. S. A., as being of great historical interest. The only reference to this matter that we have been able to find is the following from Wilcox's history of the Mex. war, p. 394-5,'' . . .

Ballentine refers to prisoners taken in the engagement at Churubusco, among them being seventy deserters from the American army. They were tried, found guilty, and hung. See p. 407, United service, 1852, pt. 3, also in his: Mexican war, by an English soldier.

[1-26664] in UE1.U5, v. 24 E.S.

Hurlbert, Wm. Henry, 1827-1895. General McClellan and the conduct of the war. N. Y., Sheldon & co., 1864. vii [9]-312 p. front., maps (1 fold.) 20cm.

. . . ''His training . . . and in the War with Mexico, chap. i, p. 9-18.

12-11031 E467.1.M2H88

Jamieson, Milton. Journal and notes of a campaign in Mexico: containing a history of Company ''C'' of the 2d regiment of Ohio volunteers; with a cursory description of the country, climate, cities, waters, roads and forts along the southern line of the American army in Mexico. Also of the manners and customs, agriculture, &c., of the Mexican people. Cincinnati, Ben Franklin print. house, 1849. iv [5]-105 p., 1 l. 21cm.

This was the 2d regiment composed of those who volunteered for ''service during the war with Mexico,'' but it was the 5th of Ohio infantry, the first three regiments being composed of twelve months volunteers.

2-15517 E411.J32

Kendall, George Wilkins, 1809-1867. The war between the U. S. and Mexico illustrated, embracing pictorial drawings of all the principal conflicts, by Carl Nebel . . . with a description of each battle, by Geo. Wilkins Kendall . . . N. Y., D. Appleton & co.; [etc., etc.], 1851. iv, 52 p. 12 col. pl. 38½ cm. In portfolio.

Plates.—1. Battle of Palo Alto. 2. Capture of Monterey. 3. Battle of Buena Vista. 4. Bombardment of Vera Cruz. 5. Battle of Cerro Gordo. 6. Assault at Contreras. 7. Battle at Churubusco. 8, 9. Battle of Molino del Rey (2 views). 10, 11. Storming of Chapultepec (2 views). Pillow's and Quitman's attacks. 12. General Scott's entrance into the city of Mexico.

9-8968 E406.A1K5 W.D.

Kenly, John Reese, 1822-1891. Memoirs of a Maryland volunteer. War with Mexico, in the years 1846-7-8. Phila., Lippincott & co., 1873. xii [13]-521 p. 22cm.

Appendix: A. List of the officers of the First battalion of Baltimore and Washington volunteers.—B. List of officers of the District of Columbia and Maryland regiment of volunteers.—C. Letter from Col. Geo. W. Hughes.—D. Treaty between the U. S. and Mexico.

2-15453 E411.K33

Lane, Wm. Bartlett, d. 1898. Our cavalry in Mexico. (In: The United service. . . . Philadelphia, 1891. 24cm. v. vi, new series, July-Dec., 1891, p. 429-450.)

in U1.U4 v. 6 new s. W.D. E.S.

Lane, Wm. Bartlett, d. 1898. The "Regiment of mounted riflemen;" or, from Puebla to the city of Mexico. (In: The United service. . . . Philadelphia, 1895. 24cm. v. xiv, new series, July-Dec., 1895, p. 301-313.)

in U1.U4 v. 14, new s. E.S.

Lane, Walter P., 1817-1892. The adventures and recollections of General Walter P. Lane, a San Jacinto veteran. Containing sketches of the Texian, Mexican, and late wars . . . Marshall, Tex., Tri-weekly herald print., 1887. 2 p. l., 114 p. front. (port.) 17cm.

In the Mexican war, Lane was a lieutenant in the 1st Texas mounted riflemen and major of the battalion of mounted Texas volunteers. In the civil war he was lieutenant-colonel of the 3d

Texas cavalry, colonel of a regiment of Texas partisan rangers, and finally brigadier-general.

11-27005 F390.L25

Late victories in Mexico. From the New Orleans Picayune of Sept. 8. (In: Littell's living age. Boston, 1847. 24cm. v. xv, Oct.-Dec., 1847, p. 22-26.)

Contains also an article from the New Orleans Delta.

[7-22282] in AP2.L65 v. 15

Lott, W. C. The landing of the expedition against Vera Cruz in 1847. Summarized by W. C. Lott, Q. M. Sergt., 1st Troop, Pa. Cavalry. (In: Military service institution of the United States. Journal. 1899. 24cm. v. 24, p. 422-428.)

Footnote: ''For most of the foregoing facts I am indebted to an interesting monograph, ''The Home Squadron in the Mexican war,'' 1896. By P. S. P. Conner, Esq.''

[8-15848] .U1.M6 v. 24 E.S.

McSherry, Rich., 1817-1885. El puchero; or, A mixed dish from Mexico, embracing Gen. Scott's campaign, with sketches of military life, in field and camp, of the character of the country, manners and ways of the people, etc. Phila., Lippincott, Grambo & co.,1850. 2 p. l., xi [13]-247 p., front., plates, fold. plan. 20cm.

Appendix (p. [199]-247): The siege of Vera Cruz [by D. H. Conrad] Cerro Gordo [by D. H. Conrad]. List of officers of the U. S. army and volunteers, who were engaged in the battles of the valley of Mexico.

Dr. McSherry served as surgeon with the regiment of marines that formed part of Gen. Scott's force from Vera Cruz to Mexico. . . . It is a sensible book by a careful observer.—Soley.

2-15558 E405.6.M17

McSherry, Rich., M. D., 1817-1885. A Mexican campaign sketch. (In: The New eclectic magazine, . . . Baltimore, 1868. 23cm. v. 3, p. 327-336.)

Describes his landing at Camp Vergara, July 3, 1847, on the beach near Vera Cruz, where Franklin Pierce was forming a brigade, ... and his further experience in the war.

[5-14024] AP2 .S84 v. 3 W.D.

Oswandel, J. Jacob. Notes of the Mexican war, 1846-47-48.

Comprising incidents, adventures, and every-day proceedings and letters while with the United States army in the Mexican war; also extracts from ancient histories of Mexico, giving an accurate account of the first and original settlers of Mexico, etc.; also the names and numbers of the different rulers of Mexico; also influence of the church. By J. Jacob Oswandel . . . Rev. 1885. Phila., 1885. 642 p. illus., port. 23cm.

Author was a member of the 1st regiment, Pennsylvania volunteers. The book consists of the journal which he kept during the war.

2-15450 E411.O86

Philadelphia grays. Artillery corps. The Philadelphia grays' collection of official reports of Brig. Gen. George Cadwalader's services during the campaign of 1847, in Mexico. Phila., T. K. and P. G. Collins, printers, 1848. 63 p. 21cm.

2-15468 E409.P54

Reid, Samuel Chester, 1818-1897. The scouting expeditions of McCulloch's Texas rangers; or, The summer and fall campaign of the army of the United States in Mexico—1846; including skirmishes with the Mexicans, and . . . the storming of Monterey; also, the daring scouts at Buena Vista; together with anecdotes, incidents, descriptions of country, and sketches of the lives of . . . Hays, McCulloch, and Walker. By Sam C. Reid, jr. Phila., G. B. Zieber and co., 1847. 251 p. front., 8 pl., 3 port., plan. 19cm.

2-15466 E405.1.R35

Reilly, James. An artilleryman's story. By James Reilly, late Ordnance sergeant, U. S. A. (In: Military service institution of the U. S. Journal. 1903. v. 33, p. 438-[447], 1909, v. 45, p. 490-496, incl. illus.

"The following narrative of service in the War with Mexico (1847-48) and in Florida (1849-57) forms part of a Ms. History of Battery M, 2d U. S. Artillery, and is published by permission of a former commander of that organization, Brig. Gen. A. C. M. Pennington, U. S. Army.—Preamble.

[6-13361] in UF1.J86,v.33 E.S.

Relic of our war with Mexico. (In: Journal of the Military service institution of the U. S., N. Y., 1882. 24cm. v. 3, no. 11.

"**Our war chest,**" p. 399. (1 outline map.)

A sketch of route taken by the 2d dragoons, July-Aug., 1845, from Fort Jesup to Corpus Christi, as the advanced guard of the army of occupation under Gen. Zachary Taylor. The relic was found among personal papers of the late Major-Gen. Meade, by his son; it was drawn by Lieut. George Stevens, 2d dragoons, acting topographical engineer, a young officer of great promise who was drowned May, 1846, while crossing the Rio Grande with a portion of his regiment to occupy the city of Matamoras. The march is fully described by one of the participants in a letter to be found in the history of the regiment. See Rodenbough, From everglade to cañon . . .

[8-15848] in U1.M6 v. 3 E.S.

Richardson, Wm. H. Journal of Wm. H. Richardson, a private soldier in the campaign of New and Old Mexico, under the command of Colonel Doniphan of Missouri. 2d ed. Baltimore, J. W. Woods, 1848. 96 p., front., illus., pl. 19cm

2-15428 E411.R53

The same. 3d ed. N. Y., W. H. Richardson, 1849. 96 p., front. (facsim.), illus. 19cm.

10-21685 E411.R54

[**Robertson, John Blount.**] Reminiscences of a campaign in Mexico; by a member of "the Bloody-First." Preceded by a short sketch of the history and condition of Mexico from her revolution down to the war with the United States. Nashville, J. York & co., 1849. 288 p., front. (fold. plan). 18cm. Preface signed: J. B. Robertson.

1-3885 E411.R64

Rodenbough, Theophilus Francis, 1838- comp. From everglade to cañon with the second dragoons (second U. S. cavalry); an authentic account of service in Florida, Mexico, Virginia, and the Indian country, including the personal recollections of prominent officers, with an appendix containing orders, reports and correspondence, military records, etc., etc., etc. 1836-1875, comp. by Theo. F. Rodenbough . . . N. Y., D. Van Nostrand, 1875. 561 p., front., illus., pl. (5 col.), 2 fold. maps. 25cm.

The war with Mexico, p. 91-146; colored plate (showing uniforms): Mexico, 1846: "Resaca"—"Before the charge," p. 91, fold. map.—The United States and Mexico, showing battlefields, marches, and stations, p. 24.—Appendix. i. Battles of the regiment. ii. Military records of officers. iii. Roll of honor. iv. Orders, reports, and correspondence. v. Index, p. [429]-561. [List of] documents. Appendix iv, p. 561.

Third period, 1845-48. The war with Mexico. ix. From New Orleans to Matamoras, p. 91-98. x. La Rosia—Palo Alto—Resaca de la Palma, p. 99-113. xi. Matamoras—Monterey—Pass of Santa Rosa, p. 114-120. xii. La Hedionda—Agua Nueva—Buena Vista, p. 121-130. xiii. Scott's operations—Vera Cruz—Medelin, p. 131-137. xiv. Antigua—Cerro Gordo—La Hoya—San Juan de los Llanos, p. 138-148. xv. Closing campaign—Molino del Rey—City of Mexico—Agua Fria, p. 149-161. Fourth period, 1848-60. California—Texas.—New Mexico. [etc., etc.] xvi. The Californian expedition—Indian and Mormon campaigns, p. 162-174 . . . . . .

Buena Vista. [Poem], by General Albert Pike, p. 129-130.

War 10-91 A.W.C.

[**Santa Anna, Antonio Lopez de**] pres. Mexico, 1795-1876. Detall de las operaciones ocurridas en la defensa de la capital de la Republica, atacada por el ejército de los Estados-Unidos del Norte. Año de 1847. Mexico, Impr. de I. Cumplido [1847?] 47 p. 22cm.

Preface dated 1847.

10-10280 E405.6.S23

Schulz, Enrique E. Batalla de Padierna, Agosto 16 de 1847. Por E. E. Schulz, Profesor de geografia en la Escuela militar preparatoria. (In: Boletin de ingenieros. Mexico, 1913. 22cm. t. iv, num. 3, p. [217]-242. 1 fold. map.)

E.S.

[**Scribner, B. F.**] A campaign in Mexico. By "One who was thar" . . . Phila., J. Gihon, 1850. [5]-75 p. front. (map). 23cm.

2-15525 E411.S44

[**Scribner, B. F.**] Camp life of a volunteer. A campaign in Mexico, or, A glimpse at life in camp. By "One who has seen the elephant." Phila., Grigg, Elliott & co.; New Albany, Ind., J. R. Nunemacker, 1847. [5]-75 p., front. (map). 23cm.

2-15524 E411.S43 W.D.

[**Sketches of the Mexican war.** [Anon.] (In: Fraser's magazine for town and country. Lond., 1848. 23cm. v. 38, p. 91-102.)

Running titles: The Texas ranger—The battle of Buena Vista.
[5-14347] in AP4 .F8 v. 38

Sketches of the war in northern Mexico. With pictures of life, manners and scenery. In two parts. N. Y., D. Appleton & co., 1848. 75 p. 14½cm.

Contents.—pt. 1. Sketches of the war.—pt. 2. Pictures of life.

2-15523 E405.1.S62

Smith, Gustavus Woodson, 1822-1896. Company "A," Corps of Engineers, U. S. A., 1846-48, in the Mexican war. By Gust. W. Smith, Capt., Engineers [Willets Point, N. Y.] The Battalion press, 1896.

An abridged edition of this book was issued with other papers in: Occasional papers, U. S. Engineer School, no. 16.

4-11992 E40.S64 E.S. A.W.C.

Smith, Isaac, of Indianapolis. Reminiscences of a campaign in Mexico: account cf [!] the operations of the Indiana brigade on the line of the Rio Grande and Sierra Madre, and a vindication of the volunteers against the aspersions of officials and un-officials. By Isaac Smith . . . 2d ed., rev., and enl. Indianapolis, Chapmans & Spahn, 1848. 116 p. 23cm.

2-15515 E405.1.S64

Smith, Robert Hall, ed. A series of intercepted Mexican letters: captured by the American guard, at Tacubaya. Aug. 22, 1847. Published by Robert H. Smith, a wounded soldier. 2d ed., enl., and improved. Columbus, O., Statesman steam press, 1848. 56 p. 22cm.

First issued in Mexico, 1847, under title: A series of intercepted letters captured by the American guard at Tacubaya.

2-15561 E411.S66

Temple, Wm. Grenville. Memoir of the landing of the United States troops at Vera Cruz in 1847. By Wm. G. Temple, U. S. N. With an appendix containing all the written orders issued by General Scott and Commodore Conner. (In: Conner, Philip S. P. The Home squadron under Commodore Conner . . . [Phila.] 1896. 25½cm. p. 57-83.)

2-15564 E410.C75

Thorpe, Thomas Bangs, 1815-1878. Our army at Monterey. Being a correct account of the proceedings and events which occurred to the "Army of occupation" under the command of Major-General Taylor, from the time of leaving Matamoros to the surrender of Monterey. With a description of the three days' battle and the storming of Monterey: the ceremonies attending the surrender: together with the particulars of the capitulation. Illus., by a view of the city and a map drawn by Lieut. Benjamin, U. S. A. By T. B. Thorpe . . . Phila., Carey and Hart, 1847. 1 p. l., vii, 9-204 p. front., pl., fold. map. 18½cm.

Added t.-p., illus., dated 1848.

2-15460 E406 .M7T5 A.W.C.

Thorpe, Thomas Bangs, 1815-1878. Our army on the Rio Grande. Being a short account of the important events transpiring from the time of the removal of the "Army of occupation" from Corpus Christi, to the surrender of Matamoros; with descriptions of the battles of Palo Alto and Resaca de la Palma, the bombardment of Fort Brown, and the ceremonies of the surrender of Matamoros: with descriptions of the city, etc., etc. Illus. by 26 engravings. By T. B. Thorpe . . . Phila., Carey and Hart, 1846. 3 p. l., [v]-ix, 11-300 p. front., illus., plates. 18½cm.

Added t.-p., illus.

On front paper cover: "Fine edition—75 cents. With official reports." "Battles on the Rio Grande. Official reports [May, 1846]": p. 197-240. "Despatches of Gen. Taylor, previous to actual hostilities [July 20, 1845-Apr. 22, 1846]": p. 241-293.

"A hasty work."—Soley.

2-15522 E405.1.T53 A.W.C.

Tyler, Daniel. A concise history of the Mormon battalion in the Mexican war. 1846-1847. By Sergeant Daniel Tyler. Salt Lake City, 1881. 1 p. l., viii [9]-376 p. 23cm.

Contents.—The martyrdom of Joseph Smith, by President J. Taylor.—The Mormons, by T. L. Kane.—The Mormon battalion, and first wagon road over the great American desert, by Miss E. R. Snow.—Mormon battalion history, by D. Tyler.

2-15527 E411.T98

U. S. Adjutant-general's office. . . . Lists of officers who marched with the army under the command of Major-General Winfield Scott, from Puebla upon the city of Mexico, the 7th, 8th, 9th and 10th of August, 1847, and who were engaged in the battles of Mexico. Mexico, American star print, 1848. [24] p. plan. 20 x 26cm. At head of title: Official.

2-15455 E405.6.U58

U. S. Adjutant-general's office. Official. List of officers who marched with the army under the command of Major-General Winfield Scott, from Puebla upon the city of Mexico, the 7th, 8th, 9th and 10th of August, 1847, and who were engaged in the battles of Mexico. Mexico, American star print, 1848. Facsimile: 24 l. 20 x 28cm.

One of the four photostatic copies made by the Library of Congress, August, 1912, from the original loaned by Brig. Gen. B. K. Roberts.

12-34276 E409.U553

U. S. Engineer dept. . . . Report of the Secretary of war, communicating, in compliance with a resolution of the Senate, a map showing the operations of the army of the United States in Texas and the adjacent Mexican states on the Rio Grande; and military memoirs of the country. Ordered to be printed . . . [Wash., D. C., Govt. print. off., 1850.) 67 p., 4 pl., 2 fold. maps, plan. 23½cm. ([U. S.] 31st Cong., 1st sess. Senate. Ex. doc. no. 32.)

''Memoir descriptive of the march of a division of the United States army, under command of Brig. Gen. John E. Wool, from San Antonio de Bexar, in Texas, to Saltillo, in Mexico. By Geo. W. Hughes, Captain, Corps topographical engineers . . . 1846.''

2-15514 E405.4.U58

Van Deusen, George William, 1859- Our artillery in the Mexican war. By First Lieut. G. W. Van Deusen, 1st U. S. artillery. (In: Military service institution of the U. S. Journal. 1895. v. 17, July, 1895, no. 76, p. 87-96.)

[6-13361] in UF1.J86 v. 17 E.S.

D.

Biographical Material.—Lives of Prominent Characters of the Mexican War, including a few Works relating to the former President, Porfirio Diaz.

BEAUREGARD.

Roman, Alfred, 1824- The military operations of General Beauregard in the war between the states, 1861 to 1865; including a brief personal sketch and a narrative of his services in the war with Mexico, 1846-8, by A. Roman . . . N. Y., Harper & bros., 1884. 2 v. fronts. (ports.), pl., map. 23cm. Preface signed: G. T. Beauregard.

Mexican war, p. 6-7.
4-22948 E547.R75

DIAZ.

Creelman, James, 1859- Diaz, master of Mexico. N. Y., and Lond., D. Appleton & co., 1911. vii [1] p. front., plates, ports. 22cm.

11-2066 F1234.D522

Ethics in action. Porfirio Diaz and his work, by a soldier of the old guard. Mexico, Impr. de Hull, 1907. 127 p. plates, ports., map, facsim. 22cm.

9-23270 F1234.D525

Fornaro, Carlo de. Diaz, czar of Mexico; an arraignment, by Carlo de Fornaro, with an open letter to Theodore Roosevelt. [Phila.] International pub. co., 1909. 154 p. front. (port.) 24cm.

9-9797 F1234.D53

Godoy, Jose Francisco, 1851- Porfirio Diaz, president of Mexico, the master builder of a great commonwealth. With 60 illus., maps and diagrs. N. Y., Lond., G. P. Putnam's sons, 1910. xii, 1 l., 253 p. front., plates, ports., fold. maps. 21cm.

10-6093 F1234.D543

Tweedie, Ethel B. (Harley). "Mrs. **Alec. Tweedie.**" The maker of modern Mexico: Porfirio Diaz, by Mrs .Alec-Tweedie (née Harley). With over 100 illus., and a map., N.Y., John Lane co.; Lond., Hurst & Blackett, ltd., 1906. xvi, 421 p. front., plates (part fold.) ports., map. 25cm.

War 8-190 A.W. C.

GRANT.

Coppee, Henry, 1821-1895. Grant and his campaigns: a military biography, N. Y., C. B. Richardson, Cincinnati, C. F. Vent & co. [etc., etc.], 1866. 521 p. front., ports., maps. 24cm.

Coppée was the editor of the United States service magazine. Mexican war, chap. iii, p. 24-26.

1-317 E672.C781

Coppee, Henry, 1821-1895. Life and services of Gen. U. S. Grant . . . Chicago, Western news co., 1868. 566 p. port., maps. 24cm.

Pub. 1866 under title: Grant and his campaigns.

1-318 E672.C781

Grant, Ulysses Simpson, pres. U. S., 1822-1885. Personal memoirs of U. S. Grant. N. Y., C. L. Webster & co., 1885-86. 2 v. front. (ports.), plates, maps, facsims. 24cm.

Mexican war, v. 1, chap. iii-xiii, p. 45-190.—Monterey and its approaches (map), facing p. 115.—Map of the Valley of Mexico, with a plan of Mexican defences and line of U. S. army's operations, facing p. 161.—The above was also republished by the above firm in 1894, and with imprint, N.Y. [n. d.], Century co., in 1909.

10-32706 E672.G76 E672.G761 E672.G7614 E.S.

HANCOCK.

Cole J. R. The life and public services of Winfield Scott Hancock, major-general, U. S. A. . . . Also, the life and services of Hon. Wm. H. English . . . Cincinnati, Douglass bros., 1880. 424 p., incl. plates. front., ports. 22cm.

Mexican war, chap. iv, p. 43-47.

11-16624 E467.1 .H2C6

Denison, Chas. Wheeler, 1809-1881. Hancock "the superb." The early life and public career of W. S. Hancock, major-general, U. S. A. . . . Including also a sketch of the life of Hon Wm. H. English . . . by Rev. C. W. Denison . . . and Capt. G. B. Herbert . . . Phila., H. W. Kelley [1880]. x, 11-431 p. front., plates, ports. 20cm.

Reissue, with additions, of the author's "Winfield; the lawyer's son," 1865.
Mexican war, chap. vii, p. 63-74. Illustration: Molino del Rey. Chapultepec in the distance, p. 64.

11-16629 E467.H2D3

Forney, John Wien, 1817-1881. Life and military services of Winfield Scott Hancock . . . his early life, education and remarkable military career . . . Also contains a succinct biographical sketch of Hon. Wm. H. English . . . By Hon. John W. Forney . . . Boston, W. H. Thompson & co. [1880], 3 p. l., 11-500 p., incl. front., illus., plates, ports., maps, plans. 19½ cm.

11-19494 E467.1.H2F7
Mexican war, p. 40-42.

Goodrich, Frederick E. The life and public services of Winfield Scott Hancock, Major-General, U. S. A. . . . with an introduction by Hon. F. O. Prince . . . Boston, Lee & Shepard; Phila., Quaker city pub. house [etc.], 1880. 375 p. front. (port.), pl. 23cm.

Mexican war, pt. ii, chap. i-iv, p. 45-69.

1-2048 E467.1.H2G6

Norton, Frank Henry, 1836- Life and public services of Winfield Scott Hancock. N. Y., Appleton & co. [1880], cover-title, 31 p. 24cm. port. and illus. on covers.

11-16633 E467.1.H2N8

Walker, Francis Amasa, 1840-1897. . . . General Hancock, by Gen. F. A. Walker. N. Y., D. Appleton & co., 1895. vi p., 2 l., 332 p. front. (port.) 6 plans. 20cm. (Half-title: Great commanders, ed. by J. G. Wilson.)

Series title also at head of t.-p.
Mexican war, chap. ii, p. 16-21.

4-17078 E467.1.H2W24

HITCHCOCK.

Hitchcock, Ethan Allen, 1798-1870. Fifty years in camp and field, diary of Major-General E. A. Hitchcock, U. S. A.; ed. by W. A. Croffut, Ph. D. N. Y., Lond., G. P. Putnam's sons, 1909. xv, 514 p. front. (port.) 25cm.

Mexican war, chap. xxvi-xliv, p 180-350.—Gen. H. served with Taylor, as commander of the 3d infantry from beginning of hostilities in 1845 to May, 1846, when, on account of dysentery from which he had been suffering all this time, he left Mexico for the States. Being somewhat improved, he again went to Mexico in Dec., 1846. In Feb., 1847, he was made Inspector-General of Scott's army and served as such in the campaign from Vera Cruz to the City of Mexico. His diary throws some interesting side-lights on the campaign, and gives some facts not related to in other histories.—Capt. [Dr.] Louis C. Duncan, Medical Corps, U. S. A.

10-186 E340.H62

JACKSON.

Henderson, Geo. Francis Robt., 1854-1903. Stonewall Jackson and the American civil war, by Lieut. Col. G. F. R. Henderson . . . Lond., N. Y. [etc.], Longmans, Green & co., 1898. 2 v., 2 port (incl. front.). 33 maps (part fold.) 23cm.

Mexican war, v. 1, p. 30-67. Map (fold.). City of Mexico and environs, p. 58.

5-32510 E467.1.J15H48 E.S.

Randolph, Sarah Nicholas, 1839- The life of Gen. Thomas J. Jackson ("Stonewall" Jackson). By Sarah N. Randolph . . . Phila., Lippincott & co., 1876. 363 p. front., plates, ports. 20cm.

Mexican war, chap. 2.

A11-2638

JOHNSTON.

Johnston, Wm. Preston, 1831-1899. The life of Gen. Albert Sidney Johnston, embracing his services in the armies of the United States, the republic of Texas, and the Confederate States. N. Y., D. Appleton & co., 1878. xviii, 755 p., incl. (maps). front. (port.), plates. 24cm.

Mexican war, chap. ix, p. 131-145.

11-22454 E467.1.J73J7 E.S.

KEARNY.

De Peyster, John Watts, 1821-1907. Personal and military history of Philip Kearny, major-general United States volunteers . . . N. Y., Rice & Gage; Newark, N. J., Bliss & co., 1869. 3 p. l., xii [13]-516 p., plates, ports., map. 24cm. Added t.-p., illus.

Mexican war, chap. x, xi, p. 123-151. Portrait: Bvt. Maj. P. Kearny, Capt., 1st U. S. Dragoons, Mexico, 1847. From portrait in possession of author, p. 128.

Kearny's march is elucidated in Emory's Notes of a military reconnaissance . . . see under U. S. Engineer dept.

"Before he started on his expedition he received orders, dated at Washington, June 3, to march across the continent from Santa Fé, and take possession of California.—Bancroft. (California, v. 5, p. 334-336.) Footnote, ibid.: "Instructions of Secretary of war, Marcy, to Col. Kearny, June 3, 1846."

11-23228 E467.1.K24D4 E467.1.K24D41 E.S.

LEE.

Long, Armistead Lindsay, 1827-1891. Memoirs of Robert E. Lee; his military and personal history, embracing a large amount of information hitherto unpublished. . . . Together with incidents relating to his private life subsequent to the war, collected and edited with the assistance of Marcus J. Wright. N. Y., Phila. [etc.], J. M. Stoddardt & co., 1886.

1 p. l., 707 p. front., illus., plates, ports., maps (3 fold.), facsim. 25cm.

The appendix (p. 501-699) contains many reports, lists, etc., relating to the army of northern Virginia.

Mexican war, chap. iii, p .47-71. Portrait: Lee, from portrait taken in 1852, p. 65. No maps of Mexico.

11-27383 E467.1.L4L8

Mason, Emily Virginia, 1815-1909. Popular life of Gen. Robert Edward Lee. Dedicated by permission to Mrs. Lee. Illus. with 17 original designs by Professor Volck. . . . 2d rev. ed. [iii]-xi, [13]-432 p. front. (port.) illus., 2 pl. 20cm.

Mexican war, chap. iii-iv, p. 36-55,incl. 1 illus., front.

Illustration: Robert E. Lee, front.—Capt. Lee wounded at Chapultepec, p. 51.

6-41948 E467.L4M3 E.S.

McCLELLAN.

Hillard, George Stillman, 1808-1879. Life and campaigns of

George B. McClellan, major-general, U. S. A. Phila., J. B. Lippincott & co., 1864. 396 p. front. (port.) 19cm.

Appendix: Oration delivered by Gen. McClellan at West Point, June 15, 1864.

. . . "Services in the Mexican war, chap. i, ii, p. 13-36. Running titles: Mexican war.—Sappers and miners.—Tompico.—Vera Cruz.—Cerro Gordo.—Amozoque.—Puebla.—Col. Totten's report.—March to Mexico.—Valley of Mexico.—Battle of Contreras.—Padierna.—Report of Gen. Twiggs.—Chapultepec.—San Cosme Garita.—Street fighting.—Close of Mexican war.—Tactics of Mexican war.—Lieut. McClellan's conduct.—Return to West Point.—Manual of bayonet exercise.

12-11030 E467.1.M2H6

Michie, Peter Smith, 1839-1901. . . . General McClellan, by Gen. P. S. Michie . . .N. Y., D. Appleton & co., 1901. ix, 489 p. 2 port. (incl. front.) 10 maps. 20cm. (Half-title: Great commanders, ed. by J. G. Wilson.) Series title also at head of t.-p.

"Ancestry.—West Point.—Mexican war," chap,. i, p. 1-23.

1-20881 E467.1.M2M6

QUITMAN.

Claiborne, John Francis Hamtramck, 1809-1884. Life and correspondence of John A. Quitman, major-general, U. S. A., and governor of the state of Mississippi. N.Y.,Harper & bros. 1860. 2 v. fronts. (v. 1, port.; v. 2, double plan). 20cm.

cf. Baylies, F. March of U. S. troops under Gen. Wool . . . Am. qu. reg., July, 1850.

1-22592 F341.Q8

SCOTT.

General Scott and his staff: comprising memoirs of Generals Scott, Twiggs, Smith, Quitman, Shields, Pillow, Lane, Cadwalader, Patterson and Pierce; Colonels Childs, Riley, Harney, and Butler, and other distinguished officers attached to General Scott's army; together with notices of General Kearny, Col. Doniphan, Col. Frémont, and other officers distinguished in the conquest of California and New Mexico. Interspereed with numerous anecdotes of the Mexican war, and personal adventures of the officers. Comp. from public documents and private correspondence. Phila., Grigg, Elliot & co., 1848. iv p. 1 l., 11-224 p. front., plates, ports. 20cm.

12-12532 E403.G32 A.W.C.

Illustrated life of Gen. Winfield Scott, commander-in-chief of the army in Mexico. Illus. by D. H. Strother. N. Y., A. S. Barnes & co., 1847. 144 p. illus. (incl. map, plan.) 21cm.

The incidents have been mainly taken from Mansfield's Life of General Scott. cf. note on cover, p. 4.

13-18456 E403.1.S4I28

Life of Gen. Winfield Scott, commander-in-chief of the U. S. army. N.Y., A. S. Barnes & co.; Bost., Redding & co. [etc., etc.]; 1852. 191 [1] p. front. (port.) illus. (incl. maps, plan). 19cm.

(At head of title: A. S. Barnes & co.'s pamphlet edition. Incidents taken from Mansfield's Life of Gen. Scott.)

13-19340 E403.1.S4L75

Mansfield, Edward Deering, 1801-1880. The life of General Winfield Scott. By E. D. Mansfield, esq. N. Y., A. S. Barnes & co., 1846. x [11]-366 (i. e., 368) p., incl. illus., maps, plans. front. (port.) plates. 20cm.

Page numbered "155*" and full page illus. not numbered, occur between p. 155 and 156.

13-16019 E403.1.S4M28 A.W.C.

Moore, H. Judge. Scott's campaign in Mexico; from the rendezvous on the island of Lobos to the taking of the city; including an account of the siege of Puebla, with sketches of the country, and manners and customs of the inhabitants. By H. Judge Moore, of the Palmetto regiment. Charleston, J. B. Nixon, 1849. xii, 234 p. 20cm.

2-15547 E405.6.M82

Scott [**Winfield**], 1786-1866. Letters of Gen. Scott and Secretary Marcy relating to the Mexican war. [Wash., Congressional globe office, 1848.] 16 p. 24cm.

2-15437 E409.S43

Scott [**Winfield**], 1786-1866. Memoirs of Lieut.-General Scott, LL. D. Written by himself. N. Y., Sheldon & co., 1864.

1 p. l., xxii, 653 p. front., port. 26cm. Large paper edition.

War with Mexico: chap. xxvi-xxxvi.—General Taylor, etc., p. 381-584.

. . . Of Scott, we have, besides the life by Mansfield his own memoirs, in which chap. 26-35 are occupied with the story of his campaign and his narrative is accompanied with some not very pleasant criminations of the President and General Taylor.—Soley. . . . . . . ''This autobiography was severely criticised in the North American review, Jan., 1865, and the Athenaeum (London) of the same month.—Edwin Erle Sparks, Prof. Am. history, Univ. of Chicago—Larned.

3-32948 E403.1S4S4

Wright, Marcus Joseph, 1831- . . . General Scott. N. Y., D. Appleton and co., 1894. xii p. 1 l., 349 p. front. (port.), 5 maps. 20cm. (Half-title: Great commanders, ed. by J. G. Wilson.)

Series title also at head of t.-p.

''For writing the military life of Scott, Gen. Wright has some peculiar qualifications. As a young soldier following his chief in the greatest of his military enterprises, the invasion of Mexico, he was a devoted subordinate on terms of personal intimacy with Scott.'' . . . Nation, v. 58, p. 417.

4-17083 E403.S4W9 A.W.C.

TAYLOR.

A **brilliant** national record. Gen. Taylor's life, battles, and despatches . . . incl., . . . letters from the President of the U. S., the War dept., . . . and the Mexican authorities. Accounts of the glorious battles of Palo Alto, Resaca de la Palma, Monterey, Buena Vista, Vera Cruz, and San Juan d'Ulloa. Comp. from authentic sources . . . Phila., T. C. Clarke [etc.] 1847. 70 p., incl. front., illus., maps, plan., port. 26cm.

13-22202 E422.B88

Conrad, Robert Taylor, 1810-1858. A sketch of the life of General Taylor, with authentic incidents of his early years. (In: Fry, Jos. Reese. A life of General Zachary Taylor; . . . q. v.)

Davis, Jefferson, 1808-1889. Speech of Hon. Jefferson Davis, of Mississippi, on the exercise of civil power and authority by military officers; delivered in the U. S. Senate, Aug. 5,

1850. [Wash., D. C., 1850.] 16 p. 24cm. Caption title. A defense of Taylor's career in the Mexican war.

10-25134 E405.1.D26

Frost, John, 1800-1859. Life of Major General Zachary Taylor; with notices of the war in New Mexico, California, and in southern Mexico; and biographical sketches of officers who have distinguished themselves in the war with Mexico. N. Y., D. Appleton & co.; Phila., G. S. Appleton, 1847. 346 p. front., illus. (incl. maps, plan, chart), plates, ports. 20cm. Title vignette.

13 22555 E422.F92

[**Fry, Joseph Reese**], 1811-1865. A life of General Zachary Taylor; comprising a narrative of events connected with his professional career, derived from public documents and private correspondence by J. Reese Fry; and authentic incidents of his early years, from materials collected by Robert T. Conrad. With an original and accurate portrait and eleven elegant illustrations of the battles of Fort Harrison, Okee-cho-bee, Palo Alto, Resaca de la Palma, Monterey, and Buena Vista, &c., &c. Designed by F. C. C. Darley. Phila., Grigg, Elliot & co., 1847. x p. 1 l., 332 p. front., pl., maps. 19cm.

Front.: Taylor.—Map of the seat of Gen. Taylor's operations in Mexico, p.2.—Taylor's first lesson in the art of war, p. 16.—Defence of Fort Harrison, p. 26.—The last charge at Okee-Cho-Bee, p. 43.—Death of Ringgold, p. 124.—May's dragoons charging the enemy's batteries, p. 183.—Diagram of defences, etc., of Monterey, p. 217.—Taylor at Buena Vista, p. 299.—Battle-ground and vicinity of Buena Vista, Feb. 22, 23, 1847, p. 300.—Field after the battle, p. 315.

13-22551 E422.F94

This ed. has good paper, and plates are clear and not worn.

Another ed. with imprint, ibid., 1848. x [11]-332 p. is printed on cheap and very poor book paper, incl. plates. A third print of this book, under title: Our battles in Mexico. Illustrated with eleven elegant engravings of the battles of Harrison [etc., etc.], was pub. by K. T. and P. G. Collins, printers, Phila., 1850. 5, vi-x, 13-344 p. illus., plates, maps, plan. 19cm.

13-22573 E422.F95, 1848 9-14015 E405.1.C75

The author's name not appearing on the title-page, the book is, in some quarters credited to R. T. Conrad, but Bancroft, in his: History of Mexico, v. p. 434, mentions Fry as the author. The reprints are poor, with plates blurred.

. . . "the life of Taylor, from his birth down to the quiet occupation by him of the positions secured by the victory of Buena Vista." The author derived his information from public documents . . . . . . which are liberally quoted, . . . Bancroft.

. . . "The best life of Taylor." . . .—Soley.

General Taylor and his staff: comprising memoirs of Generals Taylor, Worth, Wool, and Butler: Colonels May, Cross, Clay, Hardin, Yell, Hays, and other distinguished officers . . . interspersed with numerous anecdotes of the Mexican war . . . Compiled from public documents and private correspondence . . . Phila., Grigg, Elliot & co., 1848. vi, 11-284 p., incl. plates, map. front., pl., ports. 20cm.

13-22201 E403.G34

Gen. Taylor and the Mexican war. Including the particulars of the last battles, names of the killed and wounded, anecdotes, &c. N. Y., N. H. Blanchard [1847]. Cover-title [3]-18, [2] p. 25cm.

4-9703 E406.B9G3

Gen. Taylor's rough and ready almanac. 1848. Phila., R. Magee [1848]. [35] p. illus. 20cm.

Another ed. pub. same year in Baltimore, entitled: Gen. Zachary Taylor's old rough and ready almanac.

8-27443 E420.G322

Howard, Oliver Otis, 1830-1909. General Zachary Taylor. N. Y., D. Appleton & co., 1892. xii p., 1 l., 386 p. front., map, port. 20cm. (Great commanders, ed. by J. G. Wilson.)

Series t.-p. also on half-title.

"General Howard has brought together the available material for a detailed examination of his [Gen. Taylor's] military life, and, by personal visits to the battlefields of Mexico, has been able to make the history of the battles of Palo Alto, Resaca de la Palma, Monterey, and Buena Vista both interesting and intelligible to the ordinary reader. In this the maps are of great assistance, and the operations on this line in the Mexican contest are put in satisfactory form."—J. D. Cox, in Nation. v. 56, p. 18.—Larned.

13-22554 E422.H85 A.W.C.

Life and public services of Gen. Z. Taylor: including a minute account of his defence of Fort Harrison, in 1812; the battle of Okee-chobee, in 1837; and the battles of Palo Alto and Resaca de la Palma, in 1846 . . . To which is added sketches of the officers who have fallen in the late contest. Ed. by an officer of the U. S. A. N. Y., H. Long & bro., 1846. 3 p. l. [9]-56 p. fronts. (port., fold. facsim.), fold. maps. 23cm.

On cover: Long's illustrated edition.

Maps: Central Mexico, showing the contemplated route of the army.—Battles of Palo Alto and Resaca de la Palma . . . drawn by S. D. Dobbins, 1st Lieut., Adv. guards, U. S. A.

A part of this book was reprinted from the same plates in 1850.

13-22193 E422.L73

The **life** and public services of Major-General Zachary Taylor, with graphic accounts of the battles of Palo Alto; Resaca de la Palma; Monterey, and Buena Vista . . . With all his letters and despatches. Phila., N. Y., Turner & Fisher [1848?] 60 p., incl. front., illus. 19½cm.

13-22550 E422.L77

Life and public services of Gen. Z. Taylor: including a minute account of his defense of Fort Harrison, in 1812; the battle of Okee-Chobee, in 1837; and the battles of Palo Alto, Resaca de la Palma, and others . . . To which is added, sketches of the officers who have fallen in the late contest. Ed. by an an officer of the U. S. A. Also the life of Millard Fillmore . . . N. Y., 1850. 3 p. l., 5-96 p. front., illus., plates. 23cm.

9-30731 E422.L78

The **life** and public services of Major-General Zachary Taylor, with graphic accounts of the battles of Palo Alto; Resaca de de la Palma; Monterey, and Buena Vista . . . With all his letters and despatches. Phila., G. B. Zieber & co., 1847. 60 p., incl. front., illus. 19cm.

13-22192 E422.L75

The **life** of General Taylor, the hero of Okee Chobee, Palo Alto, Resaca de la Palma, Monterey, and Buena Vista. With numerous illustrative anecdotes and embellishments. Phila., Lindsay and Blakiston, 1847. viii, 9-214 p. front. (port.) plates. 18 x 14cm.

Also pub. under titles "Pictorial life of General Taylor" and "The people's life of General Zachary Taylor."

13-22548 E422.L74

Montgomery, Henry. The life of Major-General Zachary Taylor. Auburn, N. Y., J. C. Derby & co.; Buffalo, Derby & Hewson, 1847. xiv [17]-360 p. front. (port.), plates. 20cm.

13-22194 E422.M76

Montgomery, Henry. The life of Major Gen. Zachary Taylor, twelfth president of the U. S. 18th ed., rev. and enl. Auburn, Derby, Miller & co., 1849. xii [13]-413 p. front., plates, ports. 23cm.

12-36867 E422.M78

The 20th ed. was pub. ibid., 1851.—Soley.

Pictorial life of General Taylor, the hero of Okee Chobee, . . . Phila., Lindsay & Blakiston, 1847. viii, 9-214 p. col. front. (port.), col. plates. 17½cm.

cf. Note under "The life of General Taylor, the hero . . ."

13-22547 E422.L742

Powell, C. Frank. Life of Major General Taylor; with an account of his early victories and brilliant achievements in Mexico, including the siege of Monterey and battle of Buena Vista. Also sketches of Maj. Ringgold, Maj. Brown, Col. Cross, . . . etc. N. Y., D. Appleton & co.; Phila., G. S. Appleton, 1847. 121 p., port. 23cm.

Enlarged from the 1st ed. published in 1846.

13-22196 E422.P88

Quisenberry, Anderson Chenault, 1850- History by illustration. General Zachary Taylor and the Mexican war, by A. C. Quisenberry . . . Frankfort, Ky., The Kentucky state historical society, 1911. 72 p. front., pl., ports. 24cm. (Half-title: Kentucky hist. series.) Kentucky troops in the Mexican war: p. 22-27. Roster of the Kentuckians who served as officers in the war with Mexico, both in the regular army and in the volunteer army: p. 54-72.

11-22241 E409.K38

A **sketch** of the life and character of Gen. Taylor, the American hero and people's man, together with a concise history of the Mexican war . . . By the one-legged sergeant. N. Y.,

N. H. Blanchard; Boston, J. B. Hall, 1847. cover-title [3]-34 p. illus. (incl. port.). 24½cm.

13-22203 E422.S62

. . . **A sketch** of the life and public services of General Zachary Taylor, the people's candidate for the presidency. Wash., Printed by J. T. Towers [1848]. 32 p. 23½cm. Caption title.

13-22929 E422.S63

Stearns, Charles. Facts in the life of General Taylor; the Cuba blood-hound importer, the extensive slave-holder, and the hero of the Mexican war. By Chas. Stearns. Bost., The author, 1848. 35 [1], p. 18½cm.

10-5355 E422.S79

Stratemeyer, Edward, 1862- . . . With Taylor on the Rio Grande, by E. Stratemeyer . . . illus. by J. W. Kennedy. Bost., Lothrop, Lee & Shepard co. [c1909.] 287 p. front., 7 pl. 19cm. (His: Mexican war series [v. 2].)

9-10029 PZ7.S91 Wit3

Sumpter, Arthur. The lives of General Zachary Taylor and General Winfield Scott: to which is appended an outline history of Mexico, aboriginal, colonial, and republican; and a brief history of the Mexican war; including events to the surrender of the city of Mexico, and the removal of Congress to Morelia . . . By A. Sumpter, U. S. A. N. Y., H. Phelps & co., 1848. 62 [2] p., incl. front., illus., ports., map. 22cm.

Sometimes attributed to Benson J. Lossing.

11-31026 E422.S95

Taylor, Zachary, pres. U. S., 1784-1850. General Taylor's letters. Letter of Gen. Taylor to Gen. Gaines—Secretary Marcy's reprimand of General Taylor—and Gen. Taylor's reply; with the fable alluded to annexed. [n. p., 1846.] 4 p. 24cm. Caption title.

10-15746 E405.1.T24

Taylor, Zachary, pres. U. S., 1784-1850. Letters of Zachary Taylor, from the battle-fields of the Mexican war; reprinted from the originals in the collection of Mr. William K. Kirby, of St. Louis, Mo.; with introduction, biographical notes, an appendix, and illustrations from private plates. Rochester, N. Y. [The Genesee press], 1908. xxvi, 194 p., incl. front. ports., facsims. 29cm.

Introduction by William H. Samson. "Three hundred numbered copies printed for private distribution only."

8-23727 E415.T24

Taylor and Fillmore. Life of Major-General Zachary Taylor, with characteristic anecdotes and incidents. Also, life of the Hon. Millard Fillmore. Phila., T. K. & P. G. Collins, 1848. 32 p. illus. (incl. ports.) 23½cm.

13-22571 E422.T24

The same. Hartford, Belknap & Hamersley, 1848. 64 p., incl. front., illus., pl., ports. 22½cm.

13-22572 E422.T23

Taylor and his campaigns. A biography of Major-General Taylor, with a full account of his military services. With 27 portraits and engravings. Phila., E. H. Butler & co., 1848. 3 p. l. [9]-128 p. front. (port.) illus. 17½cm. Title vignette.

13-22549 E422.T25

Taylor and his generals. A biography of Major-General Zachary Taylor; and sketches of the lives of Generals Worth, Wool, and Twiggs; with a full account of the various actions of their divisions in Mexico up to the present time; together with a sketch of the life of Major-General Winfield Scott, and an account of the operations of his divisions in Mexico . . . Phila., E. H. Butler & co.; N. Y., Burgess, Stringer & co., 1847. vi [13]-325 p., incl. plates, front., ports. 19cm. Title vignette.

Slightly enlarged from an edition pub. in the same year. cf. next title.

13-22552 E422.T27

The same. Phila., E. H. Butler & co., 1847. vi [13]-318 p., incl. pl., plan. front., plates, ports. 18cm. Title vignette.

13-22556 E422.T26

The **Taylor** text-book, or Rough and ready reckoner. Baltimore, S. Sands, 1848. 58 p. 22½cm. Illus. paper cover.

13-21569 E422.T28

[**Thorpe, Thomas Bangs**], 1815-1878. The Taylor anecdote book. Anecdotes and letters of Zachary Taylor. By Tom Owen, the bee-hunter [pseud.] With a brief life . . . N. Y., D. Appleton & co.; Phila., G. S. Appleton, 1848. 2 p. l., 7-150 p. illus. (incl. port.) 23cm.

13-22200 E422.T52

Webster, Daniel, 1782-1852. [The life of General Taylor.] Remarks of the Hon. Daniel Webster, in the Senate of the United States on the resolution offered by the Hon. Mr. Downs, of Louisiana, relative to the funeral of Gen. Zach. Taylor, late President of the United States. New York Herald, July 11th, 1850. (In: North American review. Boston, 1851. 23cm. v. 72, p. 1-60.)

Running title: The life of Gen. Taylor.

[4-12673] in AP2N7

Wright, Henry Clarke, 1797-1870. Dick Crowningshield, the assassin, and Zachary Taylor, the soldier: the difference between them. Hopedale, Mass. Non-resistant and practical Christian office, 1848. 12 p. 16cm.

12-17393 E422.W95

THOMAS.

Coppee, Henry, 1821-1895. . . . General Thomas, N. Y., D. Appleton & co., 1893. x p., 1 l. [2], 332 p. front. (port.) 4 maps. 20cm. (Half-title: Great commanders, ed. by J. G. Wilson.) Series title also at head of t.-p.

"Authorities: p. [xiv].

"Early life and Mexican war, chap. i, p. 1-19.

4-17007 E467.1.T4C7

Johnson, Richard W., 1827-1897. Memoir of Major-General George H. Thomas. Phila., J. B. Lippincott & co., 1881. 322 p. front., ports. 22cm.

Mexican war, chap. ii, p. 22-25.

13-22186 E467.1.T4J6

Platt, Donn, 1819-1891. General George H. Thomas, a critical biography, by Donn Platt; with concluding chapters by Henry V. Boynton. Cincinnati, R. Clarke & co., 1893. viii, 13-658 p. front. (port.), maps. 24cm.

Mexican war, p. 63-70.

13-22931 E467.1.T4P5

Van Horne, Thomas Budd, d. 1895. The life of Major-General George H. Thomas. N. Y., C. Scribner's sons, 1882. x p., 1 l., 502 p. front. (port.), 8 fold. maps. 22½cm.

Mexican war, p. 5-9.

13-22933 E467.1.T4V2

COLLECTIONS.

Hudnut, James Monroe, 1844- pub. Commanders of the Army of the Tennessee. U. S. Grant, Wm. T. Sherman, James B. McPherson, Oliver O. Howard, John A. Logan. N. Y., J. M. Hudnut, c1884. Cover-title [2], p., 5 port. 18x14cm.

6-18146 E467.H88

Robinson, Fayette, d. 1859. Mexico and her military chieftains, from the revolution of Hidalgo to the present time. Comprising sketches of the lives of Hidalgo, Morelos, Iturbide, Santa Anna, Gomez Farias, Bustamente, Parcedes, Almonte, Arista, Alaman, Ampudia, Herrera, and De la Vega. Phila., E. H. Butler & co., 1847. ix p., 1 l. [13]-343 p. front., pl., port. 19cm.

The same. Hartford, Conn., S. Andrus & son, 1851. ix [1], [13]-343 p., incl. front. pl., port. 19cm.

2-5012-3 F1232.R65

" . . . a popular work of no great reliability, but containing some biographical information not easily found elsewhere.—Soley.

E.

The Navy of the United States

Special Works dealing with Naval Operations of the Mexican War

---

Conner, Philip Syng Physick. The castle of San Juan de Ulloa and the topsy-turvyists. Phila., 1897. Cover-title, 15 p. plans. 25cm. "Reprinted from the United service for Feb., 1897."

3-17728 E406 .V4C7

Conner, Philip Syng Physick. The Home squadron under Commodore Conner in the war with Mexico, being a synopsis of its services. (With an addendum containing Admiral Temple's Memoir of the landing of our army at Vera Cruz in 1847.) 1846-47. [Phila.?], 1896. 83 [1] p. 26cm.

2-15563 E410.C75

Dupont, Samuel Francis, 1803-1865. The war with Mexico; the cruise of the U. S. ship Cyane during the years 1845-48. From papers of her commander, the late Rear-admiral S. F. Dupont. (In: U. S. Naval institute. Proceedings. Annapolis, Md. 1882. 22cm. v. 8, no. 2, whole no. 21, p. 419-437.)

in V1.U8 v. 8

Farragut, Loyall. The life of David Glasgow Farragut, first admiral of the U. S. navy embodying his journal and letters. By his son, Loyall Farragut . . . N. Y., D. Appleton & co., 1879. vi, 586 p. illus., 3 pl., 2 port. (incl. front.) 4 plans. (1 fold.) 2 facsims. 24cm.

6-18980 E467.1F23F2 E.S.

The same. [c1907] vi, 586 p. illus., plates, 2 port. (incl. front.) maps (1 fold.) double facsim. 24cm.

7-38036 E467.1.F23F22

"Farragut goes to Vera Cruz," p. 157-158; "Peculiar service in Mexico," p. 196-198.

Griffis, Wm. Elliott, 1843- Matthew Calbraith Perry: a typical American Naval officer. Bost., Cupples and Hurd, 1887. xvi, 459 p. front. (port.), illus. 21cm.

Part performed by the navy on the east coast is well told, though too briefly. Griffis's name is a guarantee of accuracy, and his work shows literary taste and skill. His material was derived from original sources . . . Useful in bringing out the importance of the naval operations, which military writers have an apparently uncontrollable tendency to slight.—Soley.

4-17022 E182.P46

Jones, Chas. Colocock, jr., 1831-1893. The life and services of Commodore Josiah Tattnall. Savannah, Morning news steam print. house, 1878. ix, 255, 4 p. front. (port.) 24cm.

Chap. 6 to be consulted for the important services of the Mosquito Flotilla on the east coast.—Soley.

13-22920 E467.1.T2J7

Maclay, Edgar Stanton, 1863- A history of the United States navy, from 1775 to 1893; by E. S. Maclay, A. M., with technical revision by Lieut. Roy C. Smith. N. Y., D. Appleton & co., 1894. 2 v. fronts., illus., plates, maps. 23cm.

War in the Mexican Gulf, chap. vi, p. 171-190, incl. 1 sketch map.

Running titles: First failures.—Expedition to Tabasco.—Cutting out the Creole.—Bombardment of Vera Cruz.—Tattnall's audacious attack.—Work of the naval battery.—Losses in the naval battery.—Fall of Tuspan.—Second attack on Tabasco.

2-7190 E182.M18 E.S.

The same. New ed., rev. and enl. N. Y., Appleton & co. [1898] 2 v. front., illus., pl., maps. 23cm.

2-7191 E182.M20

The same. v. 3 . . . N. Y., D. Appleton & co., 1902. front., illus., pl. 23cm.

2-12716 E182.M211

Mahan, Alfred Thayer, 1840- . . . Admiral Farragut, by Capt. A. T. Mahan . . . N. Y., D. Appleton & co., 1901. 3 p. l., 333 p. front. (port.) fold. map, 4 plans (1 fold.) 20cm. (Half-title: Great commanders, ed. by J. G. Wilson.) Series title also at head of t.-p.

[Mexican war], p. 94-97. Running title: Commander and captain.

4-17351 E467.1F23M21

Parker, Wm. Harwar, 1826-1896. Recollections of a naval officer, 1841-1865, by Capt. Wm. H. Parker. N. Y., C. Scribners [!] sons, 1883. xv, 372 p. 20cm.

For a vivid picture of naval life in the Mexican war period, there is nothing comparable . . . It is as entertaining as a romance and as accurate as a photograph. His style is anecdotic and racy, but his facts are faithfully presented, his judgments are sound to the core, and his impressions are sharply outlined. Capt. Parker, then a midshipman, served in the squadrons of Conner and Perry on the east coast, and took part in all prominent operations. He was present at the capture of Vera Cruz taking his tour of duty in the naval battery.—Soley.

8-1165 E596.P24

[**Phelps, Wm. D.**] Fore and aft; or, Leaves from the life of an old sailor. By ''Webfoot'' [pseud.]. With illus. by Hammatt Billings. Bost., Nichols & Hall, 1871. vi [7]-359 p. front., plates. 18cm.

8-21257 G540.P6

Revere, Joseph Warren, 1812-1880. Keel and saddle: a retrospect of forty years of military and naval service. Boston, J. R. Osgood & co., 1872. xiii, 360 p. 19½cm.

. . . ''a pleasant, chatty book of naval and other experiences, part of which (p. 42-50) refers to Stockton's campaign. cf. Phelps, W. D. Fore and aft. Boston, 1871.—Soley.

13-5287 F1213.R45

Rowan, Stephen Clegg, 1882- Recollections of the Mexican war. Taken from the Journals of Lieut. Stephen C. Rowan, U. S. navy, executive officer of the U. S. S. Cyane, Pacific squadron, 1845-1848. (In U. S. Naval institute. Proceedings, Annapolis, Md. 1888. 22cm. v. 14, no. 3, whole no. 46, p. 539-559.)

in V1.U8 v. 14

Semmes, Raphael, 1809-1877. Service afloat and ashore during the Mexican war: by Lieut. Raphael Semmes . . . Cincinnati, W. H. Moore & co., 1851. xii [7]-480 p. front. (plan.) 6 pl. 21cm.

An abridged edition of this work was issued in 1852, under title: The campaign of General Scott, in the valley of Mexico.

. . . The campaign of the army from Vera Cruz to Mexico is treated in the latter part of his ''Service afloat.'' During this campaign Semmes acted as aide-de-camp to General Worth.—Soley.

2-15472 E404.S47 W.D. E.S. A.W.C.

Soley, James Russell, 1850- . . . Admiral Porter, by James R. Soley . . . N. Y., D. Appleton and co., 1903. vii p. 1 l., 499 p. front., plates, ports., maps, facsim. 19½cm. (Half-title: Great commanders, ed. by J. G. Wilson.)

3-24307 E467.1.P78S6

Taylor, Fitch Waterman, 1803-1865. The broad pennant: or, A cruise in the U. S. flagship of the Gulf squadron during the Mexican difficulties; together with sketches of the Mexican war, from the commencement of hostilities to the capture of the city of Mexico. By Rev. Fitch W. Taylor . . . N. Y., Leavitt, Trow & co., 1848. 415 p. front. 19cm.

Touches the east-coast operations.—Soley.

2-15552 E410.T24

[**U. S.** Navy dept.] Annual report of the secretary of the navy [signed]: J. Y. Mason, Dec. 6, 1847. (**In: U. S. President, 1845-1849 (Polk), Message of the President . . . at the commencement of the first session of the 30th Congress.** Wash., 1848. 23cm. v. 1, doc. 1, p. 945-959.)

''List of deaths in the navy, as ascertained at the department since Dec. 1, 1846,'' p. 960-962, and other tables, p. 963-976.

U. S. Navy dept. . . . Number, etc., of persons employed in the naval and marine service in the Mexican war. Letter from the secretary of the navy, in answer to a resolution of the House of the 20th Dec., 1848, relative to the number and places of birth of persons employed in the naval and marine service on the Gulf and Pacific coasts during the Mexican war. [Wash., D. C., 1849.] 5 p. 24cm. ([U. S.] 30th Cong., 2d sess. House. Ex. doc. 24.) Caption title. Jan. 6, 1849. Laid upon the table and ordered to be printed.

8-33588 E410.U57 Cong. doc. Serial 540

F.

Modern Mexico

Including Description of, and Travel in, Mexico; Natural Resources, Social Life and Customs, Politics and Government, Economic Conditions, the Army and Navy, and Recent Events in Mexico.

Aguilar y Santillan, Rafael. . . . Madero sin máscara. 1. ed. Mexico, Impr. Popular, 1911. Cover-title, 109 p., incl. illus. (maps), facsim. 22cm. Port. on cover.

12-23446 F1234.M19

Arnold, Channing. The American Egypt, a record of travel in Yucatan, by Ch. Arnold and Fred. J. Tabor Frost. Lond., Hutchinson & co., 1909. xiv, 391 [1] p. front., illus. (incl. plans), plates, fold. map. 25cm.

Published also New York, 1909.

11-16726 F1876.A75

Baerlein, Henry. Mexico, the land of unrest; being chiefly an account of what produced the outbreak in 1910, together with the story of the revolution down to this day. Lond., Herbert and Daniel [1913]. 2 p. l., vii-xxvi, 461 [1] p. front., plates, ports., fold. map. 23cm.

13-22126 F1234.B14

The same, with imprint: Phila., J. B. Lippincott co. [1913].

E.S.

Author was special correspondent of The Times (London) in Mexico. The work is of particular interest as it is the only known record available at this time which tells the complete story of the Mexican revolution from the outbreak in 1910 down to the present day. Porfirio Diaz, Francisco Madero, and a number of other prominent characters are clearly depicted; there is also a brief life of the constitutionalists' leader Villa.

Barton, Mary. Impressions of Mexico with brush and pen. Lond., Methuen & co., ltd. [1911]. xi, 163 [1] p. front., mounted col. plates. 23cm.

11-15617 F1215.B29

Bellemare, Louis, i. e. **Eugène Louis Gabriel de,** 1809-1852. Scènes de la vie militaire au Mexique, par Gabriel Ferry (Louis de Bellemare), Paris, Hachette, 1858. 3 p. l. [3]-295 p., 2 l. 19cm. (Bibliothèque des chemins de fer.)

11-30503 F1213.B42

[**Bellemare, Louis,** i. e., **Eugène Louis Gabriel de,** 1809-1852], Vagabond life in Mexico. N. Y., Harper & bros., 1856.

Contents.—Perico, the Mexican vagabond.—Fray Serapio, the Franciscan monk.—Don Tadeo Christobal, the thieves' lawyer of Mexico.—Remigio Vasquez.—The miners of Rayas.—Captain Don Blas and the silver convoy.—The Jarochos.—The pilot Ventura.

6-11706 PZ3.B419V

Bigot, Raoul. Le Mexique moderne. [3 éd.] Paris, P. Roger & cie. [1909.] 2 p. l. [7]-272 p. front., plates. 21cm. (Collection ''Les pays modernes.)

11-19563 F1226.B59

Blichfeldt, Emil Harry, 1874- A Mexican journey. N. Y., Crowell co. [1912], viii, 280 p. front., plates, ports., fold. map. 22cm.

Bibliography: p. 271.

''Most of what appears in the following pages was first written for the Chautauquan magazine.''—Pref.

The author, who has had three years' close contact with the people in Mexico, takes his reader through Yucatan, Vera Cruz, Oaxaca and Mitla to the capital city, mingling guide-book information and personal knowledge in a familiar narrative, discussing various aspects of the development of the country, and giving at length his view of the present political situation. A timely work, well indexed and illus.

12-23775 F1215.B7 E.S.

Brady, Austin C. Mexico's fighting equipment. (In: Review of reviews, N. Y., 1906. 24cm. v. 34, Nov., 1906, p. [575]-582, incl. illus.)

[11-3099] in AP2R4 v. 34

Burford, Robt., 1791-1861. Description of a view of the City of Mexico; and the surrounding country, now exhibiting at the Panorama, Leicester square. Painted by the proprietor, Robt. Burford, assisted by H. C. Selous. Lond., Printed by W. J. Colbourn, 1853. 20 p. front. (fold. plan.) 21cm.

11-4016 F1386.B965

Calderon de la Barca, Frances Erskine (Inglis). Life in Mexico during a residence of two years in that country. By Madame C— de la B— . . . With a preface, by W. H. Prescott . . . Lond., Chapman & Hall, 1843. xiv, 437 p. 22cm

2-4774 F1213.C14

Campbell, Reau. Campbell's new revised complete guide and descriptive book of Mexico. Chicago [Rogers & Smith co.] 1909. vi, 7-352 p. front. (port.) illus., fold. map. 19cm. First ed., 1895.

Contents.—Geographical: Rivers, lakes, harbors, mountains, table-lands, seaports, ... climate, railroads, steamer lines, p. 7-21.—Historical, p. 23-42.—Practical matters, p. 43-60.—Amusements, p. 61-70.—The city of Mexico, p. 71-121. —Around the valley, p. 121-154.—Cities and towns of Mexico, p. 155-267.—Railway rides in Mexico, p. 269-320.—The United States of Mexico, p. 321.—Location, population and altitudes, p. 322.—Street car lines, p. 324.—Table of terms, p. 327-337.—Chronological, p. 339-345.—Index, 347-352.

Maps (fold.). City of Mexico, on one side. Mexico (col.) Scale, 72 statute miles to 1 inch, on reverse side.

8-37653 F1209.C192 A.W.C.

Carson, Wm. English, 1870- Mexico, the wonderland of the South. N.Y., The Macmillan co., 1909. xi, 439 p. front., plates, ports., map. 20cm.

A traveler's tale picturesquely contrasting old and new phases of Mexican life, describing cities, mines, haciendas and health resorts, and relating out-of-door experience. More deliberately informing than Flanderau's Viva Mexico, but less entertaining and significant. cf. Enoch, p. 114.

9-29345 F1215.C32 A.W.C.

. . . **Conditions** in the Republic of Mexico. A statement of the conditions in the Republic of Mexico with relation to the Diaz and Madero régime and the Huerta "de facto" government . . . Wash., D. C. [Govt. print. off.], 1913. 14 p.

23cm. ([U. S.] 63d Cong., 1st sess. Senate. Doc. 153.) Presented by Mr. Sheppard. Ordered printed Aug. 6, 1913.

A statement of the "Constitutionalist" position.

13-35641 F1234.C74

Cooke, Philip St. George, 1809-1895. Scenes and adventures in the army: or, Romance of military life. Phila., Lindsay & Blakiston, 1857. xii [13]-432 p. 19cm.

Rc-1185 F592.C77

Dollero, Adolfo. México al dia (impresiones y notas de viaje) . . . Paris [etc.] Vda de C. Bouret, 1911. 972 p. illus. 23cm.

11-17481 F1215.D65

Enock, C. Reginald, 1868- Mexico: its ancient and modern civilisation, history and political conditions, topography and natural resources, industries and general development; with an introduction by Martin Hume. . . . N. Y., Scribners, Lond. Unwin, 1909. xxxvi, 362 p. 75 pl. (incl. front.) fold. map. 23cm. (Half-title: The South American series, ed. by Martin Hume.) Title in red and black.

Bibliography: p. xxi-xxiii.

Combined history, archaeology and description based on reading and travel. The author has not availed himself of the latest scholarship with reference to the Spanish conquest, but his later history is sound, his descriptions of modern life and scenery picturesque, and he gives an exhaustive and instructive survey of natural resources and industrial conditions. The book is illustrated by admirable photographs and has an annotated bibliography, index and folding map. Covers modern conditions as thoroughly and is much less expensive than Martin's Mexico of the 20th century . . ., is much more popular in style and would prove an acceptable substitute on modern Mexico, but contains much less history.

9-22998 F1208.E59 A.W.C.

Flandrau, Chas. Macomb, 1871- Viva Mexico! N. Y., D. Appleton & co., 1908. 4 p. l., 293 [1] p. 18cm.

Partly reprinted from "The Bellman."

Impressions of an American resident, presenting a vivid picture of present-day Mexican life. Not exhaustive nor very instructive, but breezy, humorous and thoroughly readable.

8-28075 F1215.F58 A.W.C.

Gadow, Hans Friedrich, 1855- Through southern Mexico, being an account of the travels of a naturalist. With over 160 full page and other illustrations and maps. Lond., Witherby & co.; C. Scribner's sons, 1908. xvi, 527 p. incl. illus., plates. front., fold. map. 23cm.

9-6066 F1215.G12 A.W.C.

Gillpatrick, Owen Wallace. The man who likes Mexico; the spirited chronicle of adventurous wanderings in Mexican highways and byways. Illus. with photographs. N. Y., Century co., 1911. 10 p. l., 3-374 p., incl. plates, port. front. 22cm.

11-28340 F1215.G48

Goodrich, Joseph King. . . . The coming Mexico. With 32 illus. from photographs. Chicago, McClurg & co., 1913. xii p., 1 l., 280 p. front., plates. 20cm. (His: The world to-day series.)

Bibliography: p. [265]-269.

13-5571 F1208.G65

Iglehart, Mrs. **Fanny (Chambers) Gooch.** Face to face with the Mexicans: the domestic life, educational, social, and business ways, statesmanship and literature, legendary and general history of the Mexican people, as seen and studied by an American woman during seven years of intercourse with them. By Fanny Chambers Gooch, N. Y., Fords, Howard & Hulbert [c1887], 584 p. incl. front., illus., plates (partly col.), port., facsim. 25cm.

Contains a few national airs.—''A faithful account of what the author saw.'' The historical chapters are derived from Brantz Mayer, Prescott, and the talk of the drawing room.—Soley.

2-4844 F1215.I24 A.W.C.

International bureau of American republics, Washington, D.C. . . . Mexico. General descriptive data prepared in June, 1909. Wash., Govt. print. off., 1909. 33 p. illus. 25cm.

At head of title: International bureau of American republics. John Barrett, director. (Francisco J. Yanes, secy.) Superseded by new edition issued under the bureau's new name: Pan-American union, q. v.

9-35702 HC131.A7 1909 A.W.C.

Kendall, John Smith, 1874- Seven Mexican cities. New Orleans, La., Picayune job print, 1906. 63 p. illus. 24cm.

Brief description of Tampico, Guanajuato, Queretaro, the city of Mexico, Vera Cruz, Merida and Progreso.

7-21561 F1215.K33

Kirkham, Stanton Davis, 1868- Mexican trails; a record of travel in Mexico, 1904-1907, and a glimpse at the life of the Mexican Indian. Illustrated from original photographs by the author. N. Y., and Lond., G. P. Putnam's sons, 1909. xvii, 293 p. front., 23 pl. 21cm.

Entertaining sketches of village life in Mexico, the record of three years' residence and wandering over a large part of the country. Gives a very good idea of local conditions and of the status of Mexican Indians. There are many good illustrations.

9-7928 F1215.K59

Lemcke, Heinrich. Mexiko: das land und seine leute. Ein führer und geographisches handbuch unter besonderer berücksichtigung der gegenwärtigen wirtschaftlichen verhältnisse des landes. Berlin, A. Schall, 1900. viii [2] p, 1 l., 290 p. front. (port.) illus., pl., map. folio.

2-4732 F1208.L55

Lumholtz, Karl Sofus, 1851- New trails in Mexico; an account of one year's exploration in northwestern Sonora, Mexico, and southwestern Arizona, 1909-10. With numerous illus., including two color plates and two maps. N.Y., C. Scribners, 1912. xxv p., 1 l., 411 p. col. front., plates (1 col.) 2 fold. maps (in pocket). 25cm.

12-23778 F1346.L95

Lumholtz, Karl Sofus, 1851- Unknown Mexico; a record of five years' exploration among the tribes of the western Sierra Madre; in the Sierra Caliente of Tepic and Jalisco; and among the Tarascos of Michoacan. N. Y., Scribners, 1902. 2 v. fronts., illus., plates (partly col.) ports., facsims., fold. maps. 25cm. Bibliography: v. 1, p. xv-xvi.

2-27727 F1215.L93 A.W.C.

Martin, Percy Falcke, 1861- Mexico of the twentieth century. Lond., E. Arnold [N. Y., Dodd, Mead & co.], 1907. 2v. fronts., plates, ports., 2 fold. maps. 22cm.

A valuable compendium of information concerning the political, industrial, economic, and social conditions, the natural resources, manners and customs, the archaeology, education—in short, every phase of national life. Sufficient attention is given the history to understand present-day conditions. Readable, letter-press excellent, illustrations admirable, binding only fairly durable.

Particular attention is called to the following pages, etc. **v. 1.** Distribution of Mexican army.—Military instruction.—Organization.—Equipment.—Navy, etc., p. 41-50.—Central railway, ... Port of Manzanillo—Rolling stock—. . . p. 258-268—Kansas City, Mexico and Orient railway, p. 269-277—British-owned railways, p. 278-289—Some minor railways, p. 290-296—Steamship lines, p. 297-304—Ports and harbors, p. 305-316—Port of Manzanillo, p. 317-323. Illustrations.—**v. 1.** Types of Mexican army, p. 22,30—General subinspector of Rurales, p. 38—General Juan Quintas y Arroya, p. 46—Port of Manzanillo. General view of breakwater, p. 306—Entrance to harbor, p. 318—Plan of Manzanillo harbor, at end of volume. **v. 2.** Wharf at Tampico, p. 130—Jalpa Dam: state of Guanajuato, p. 180—Map of Mexico at end of volume.

8-4360 F1208.M37

Maxson, Harold R. A practical up-to-date guide to Mexico City and vicinity with excursions to Toluca, Amecameca, Yochimilco, Cuernavaca and San Juan Teotihuacan. Mexico City, American book & print. co., 1907. [2], 239 [3] p. illus., fold. map. 17½cm. cover-title: Hoeck's guide to Mexico.

War 8-35 A.W.C.

Mayer, Brantz, 1809-1879. Mexico as it was and as it is: by Brantz Mayer. With numerous illus. on wood, engraved by Butler from drawings by the author. N. Y., J. Winchester [etc., etc.], 1844. 3 p. l. [v]-xii, 390 p. front., illus., plates, plan, facsim. 24cm. Title vignette.

The same. 3d ed., rev. and corr., with the historical portion brought down to the present time. Phila., G. B. Zieber & co., 1847. 2 p. l. [xi]-xv, [ix]-xii, 390 p. front., illus., plates. 24cm.

. . . ''an honest record, but the author, despite his official position [that of consul] apparently neither saw nor understood much of the people or the true state of the country. The historical chapters are untrustworthy.—Soley.

2-4796 2-4797 F1213.M46 F1213.M48

The **Mexican** year book, 1908-1913. Comprising historical, statistical & fiscal information. Compiled from official and other records. . . . Issued under the auspices of the Dept. of finance. London, McCorquodale & co., ltd.; N. Y. [etc.] Brentanos [etc.], 1908-1913. 6 v. in 5. front. (port.) plates, fold. maps. 23cm.

Imprint varies. Issue for 1914 is promised in March, 1914. The first volume was the issue for 1908. This contains a port. (front.) of Porfirio Diaz.

Contents (in part).—1908. Defense, p. 125-127; 976.—Transportation and communications, p. 325-433; 977-978.—Harbors and port dues, p. 717-736.—Maps showing Railway lines, p. 368-369, etc.

1909-1910 (in 1 v.). Contains: ''Present status of army and navy, p. 79-81.—Railroads and communications, p. 285-374.—Tehuantepec national route and steamship connections. Frontispiece. This v. contains also maps showing the Railway routes.

1912. Contains: Railroads and the republic, p. 79-81.—The National railway system and government owned lines, p. 82-88.—Independent railways, p. 89-93.—Relations with foreign nations, p. 191-195.—Posts and telegraphs, p. 196-197.—No chapter on army and navy.

9 241 F1201.M61 E.S.1914

Mexico. Ministerio de guerra y marina. Memoria. Mexico. Tip. de la oficina impresora de estampillas [etc.]. 1830-1901. 26 v. in 31. plates (part fold.) fold. maps, fold. tables and atlas. 25½-33½cm.

Report year irregular.

Memoria de la secretaria de estado y del despacho de guerra y marina [etc., etc.]. Title varies slightly.—1830-1831, 1834 have added t.-p.: Memoria de marina [etc.].—1869 has title: Memoria que el C. general de division Ignacio Mejia ministro de guerra y marina presenta al 7e Congreso constitutional. Mexico, Imprenta de gobierno, 1873.—1881 issued in 2 v.—1896-99 issued in 6 v. incl. ''Atlas'' of 163 pl. (part fold.) and ''Supplemento.''—1900-1901 issued in 3 pts.: ''Parte expositiva'' and ''Anexos.''

5-31551 UA603.A18

Mexico. Ministerio de guerra y marina. . . . Ordenanza general del ejército . . . [11 de diciembre de 1911. México, 1912.] 75 p., 1 l. 32½cm.

At head of title: Diario oficial.—Ordenanza general del ejército. Secretaria de estado y del despacho de guerra y marina. México. —Departamento de Estado mayor.—Decreto numero 424 . . .

Issued in sheets with the Diario oficial, enero-febr., 1912.

13-11692 UB511.A5 1911

Mexico (City). Committee of the American colony. Facts submitted by the Committee of the American colony to President Wilson and Secretary of State Bryan relative to the Mexican situation and the record of the Hon. Henry Lane Wilson therewith. [n. p.] The Committee [1913]. 39 p. 23cm.

War13-194 A.W.C.

Le **Mexique** au début du XXe siècle, par MM. le prince Roland Bonaparte, Léon Bourgeois, Jules Claretie, d'Estournelles de Constant, A. de Foville, Hippolyte Gomot, O. Gréard,Albin Haller, Camille Krantz, Michel Lagrave, Louis de Launay, Paul Leroy-Beaulieu, E. Levasseur, le général Niox, Alfred Picard, Élisée Reclus . . . Paris, C. Dèlagrave [1904] 2v. illus., plates, maps (partly fold.) 30½cm.

Contents.—t. I. Levasseur, E. Introduction générale.—Reclus, E. Aperçu géographique.—Bonaparte, R. Population et colonisation.—Bourgeois, L. Institutions politiques, judiciaires et administratives.—Gomot, H. Agriculture.—Launay, L. de Mines et industries minières.—Picard, A. Industrie, commerce et navigation. t. 2. Krantz, C. Chemins de fer et travaux publics.—Lagrave, M. Postes et télégraphes.—Foville, A. de Monnaies, change et banques.—Leroy-Beaulieu, P. Finances.—Gréard, O. Instruction publique.—Haller, A. Sciences.—Claretie, J. Art et litterature.—Niox, G. L. Armée et marine.—Estournelles de Constant, P. H. B. d'Relations extérieures.—Levasseur, E. Conclusion générale.

5-13278 HC135.M6

Moler, Arthur B., 1866- Mexico; the diary of a trip taken by A. B. Moler and wife, Feb., 1912; illus., courtesy National railways of Mexico. [Chicago, Ill., Printed by Legal news co.] c1912. [16] p. illus. 27½cm.

12-9162 F1215.M71

Morales, Vicente. El Señor Root en Mexico; cronica de la visita hecha en octobre de 1907 al pueblo y al gobierno de la Republica Mexicana, por Su Excelencia el Honorable Señor Elihu Root, secretario de estado del gobierno de los Estados Unidos de América. La escriben: Vicente Morales y Manuel Caballero, por acuerdo de la Comision organizadora de festejos en honor del Sr. Root. Mexico, Impr. de ''Arte y letras,'' 1908. 314 [1] p. incl. illus., ports. 26½x19cm.

Spanish and English in parallel columns. ''Traducción al inglés por Luis D'Antin.''

10-20285 F1234.M82

Moses, Jasper T. To-day in the land of to-morrow; a study in the development of Mexico. Indianapolis, Ind., Christian woman's board of missions, 1907. x, 83 p. 25 pl. 24cm.

Bibliography: p. 81-83.

Description of the country, the customs and mode of life of the people, with chapters on education and the progress of missions in Mexico.

7-29103 F1215.M91 A.W.C.

Oswald, Felix Leopold. Summerland sketches; or, Rambles in the backwoods of Mexico and Central America. Phila., J. B. Lippincott co., 1880.

For eight years the author traveled through the highlands of Jalisco, Oxaca, Colima and Vera Paz in Mexico, and through Yucatan and the backwoods of Guatemala. His book is interesting as isolated sketches, but is too sketchy to serve as a guide-book to the region.

2-4857 F1215.O86

Palmer, Frederick, 1873- Central America and its problems; an account of a journey from the Rio Grande to Panama, with introductory chapters on Mexico and her relations to her neighbors, by Fred. Palmer, F. R. G. S. N. Y., Moffat, Yard & co., 1910. xiv, 347 p. front., plates, fold. map. 22cm.

10-3394 F1431.P17 A.W.C.

Pan American union, comp. Mexico; a general sketch, comp. by the Pan American union, John Barrett, director general, Francisco J. Yánes, assistant director. Wash., D. C. [Press of B. S. Adams], 1911. 389, xvii p. front. (port.), illus., 2 pl., 4 fold. maps. 23½ cm. Bibliography: p. 388-389. Errata slip attached to t.-p.

A comprehensive, up-to-date handbook giving data on Mexican archaeology, history, geography, topography, climate, resources, finances, laws, civil and military affairs, and other matters of interest to intending investors, colonists or tourists. It is too statistical to be of interest for general reading, but for reference is the best single volume available. Many illus. from photographs, tables, charts and excellent folding maps. It contains a Bibliography of 1½ pages, and an index.

11-35113 F1208.P18 E.S.

Romero, Matias. 1837-1898. Geographical and statistical notes on Mexico by Matias Romero. N. Y., and Lond., Putnams, 1898. xiv p., 1 l., 286 p., pl., map. 26cm.

Forms also p. 1-280 of his "Mexico and the United States," and "Coffee and india rubber culture in Mexico."

An advance issue, under an admirably descriptive title, of the first pages of Sr. Romero's very poorly named "Mexico and the United States," in which these pages are inserted without note or comment, an exceedingly valuable compendium upon the country of Mexico as it was known to the Mexican minister to the United States.—Soley.

A.W.C.

Romero, Matias, 1837-1898. Mexico and the United States; a study of subjects affecting their political, commercial and social relations, made with view to their promotion; by Matias Romero. Volume 1. N. Y., and Lond., Putnams, 1898. xxxv p., 1 l., 759 p. map, facsim., 2 diagr. 26cm.

No more published. Complete in 1 volume.

. . . The historical portion of this bulky volume consists of revisions and enlargements of articles originally printed in magazines. Although frequently characterized by the sophistry of logic which assumes the truth of stated premises, this volume is probably as good a work as exists in English on the significance of the history of the 19th century Mexico.—Soley.

98-1156 F1208.R76 A.W.C.

Skinner, H. B. Mexico in miniature; or, A statistical and historical view of the whole country: giving a description of its most important cities, towns, churches, clergy, church-property, population, mines, manufactories, exports, rivers, lakes, mountains, climate, seaports, and harbors, army, navy, etc. Together with an explanation of the route and progress of our army, description of battles fought, and naval operations . . . By H. B. Skinner. Bost., J. B. Hall, 1847. 1 p. l., 16 [1] p. illus., fold. map. 23cm.

2-15549 E409.S62

Smith, Francis Hopkinson, 1838- A white umbrella in Mexico, by F. H. Smith. With illus. by the author. Bost., and N. Y., Houghton, Mifflin and co., 1889. viii, 227 p. illus. 18½cm.

2-4868 F1215.S64 A.W.C.

Steele, James William, 1840-1905. To Mexico by palace car. Intended as a guide to her principal cities and capital, and generally as a tourist's introduction to her life and people. Chicago, Jansen, McClurg & co., 1884. 95 p., incl. front., illus. 15x12cm.

2-4870 F1215.S81

Terry, Thomas Philip, 1864- Terry's Mexico; handbook for travellers. With two maps and 25 plans. City of Mexico, Sonora news co.; Boston, Houghton, Mifflin co., 1909. 2 p. l. [iii]-ccxl, 595 [1] p. 2 maps (incl. fold. front.) 25 plans (1 fold.) 16cm.

Bibliography: p. ccxxxix-ccxl.

A guide book in close imitation of Baedeker's in subject-matter, arrangement, typography and binding. It shares that excellent series' good points also as to accuracy, and is based on long familiarity with the country.

[Short notes on] Army and navy, p. cxxvi-cxxvii.—Mexican river system, p. cxxvii.

10-870 F1209.T32 A.W.C.

Thompson, Waddy, 1798-1868. Recollections of Mexico. N.Y., and Lond., Wiley and Putnam, 1846. x, 304 p. 22½cm.

These impressions of the country, as seen by the United States minister, make no pretensions to scholarly accuracy or to critical insight. A well-written work, in which distinct traces are visible in the existing notions held by the people of the U. S. in regard to Mexico.—Soley.

2-4808 F1213.T47

Tilden, Bryant P., jr. Notes on the upper Rio Grande . . . explored in the months of October and November, 1846, on board the U. S. steamer Major Brown, commanded by Capt. M. Sterling . . . By order of Major-General Patterson . . . Phila., Lindsay & Blakiston, 1847. 32 p. fold. maps. 24cm.

1-11953-M1 F392.R5T5

Turner, John Kenneth. Barbarous Mexico. Chicago, C. H. Kerr & co., 1911. 5 p. l., 9-340 p. plates, ports. 20cm.

10-30095 F1215.T94

Tyler, Robert Enoc, 1869- Mexico, past, present, future [by] Rev. Robt. E. Tyler. Birmingham, Ala. [Printed by Leslie print. co.], 1912. 3 p. l. [11]-235 p., plates, port. 19½cm.

12-20142 F1208.T98

U. S. Congress. House. Committee on rules. Hearings on H. J. res. 201 providing for a joint committee to investigate alleged persecutions of Mexican citizens by the government of Mexico. Hearings held before the Committee on rules, House of representatives, United States, June 8, 10, 11, 13, and 14, 1910 . . . Wash., D. C., Govt. print. off., 1910. 95 p. 23cm.

John Dalzell, chairman. Running title: Alleged persecutions of Mexican citizens. Statements of Wm. B. Wilson, of Pennsylvania. L. Gutierrez de Lara, and others.

11-18998 F1234.U58

U. S. War dept. . . . Claims growing out of insurrection in Mexico. Letter from the Secretary of war transmitting, pursuant to Senate joint resolution 103 of the 62d Congress, report of commission appointed by the War department to investigate the claims of American citizens for damages suffered within American territory and growing out of the late insurrection in Mexico . . . [Wash., D. C., Govt. print. off.] 1912. 621 p. fold. maps. 23cm. ([U. S.] 62d Cong., 3d sess. House. Doc. 1168.)

Referred to the committee on foreign affairs and ordered printed Dec. 13, 1912. "Letter of submittal" signed: F. J. Kernan, adjutant general, for the commission.

13-35036 F1234.U63

Winter, Nevin, Otto, 1869- Mexico and her people of to-day; an account of the customs, characteristics, amusements, history and advancement of the Mexicans, and the development and resources of their country. Illus. from original photographs by the author and C. R. Birt. Boston, L. C. Page & co., 1907. 3 p. l., v-vi p., 1 l., vii-viii, 405 p. front., 47 pl., 2 fold. maps. 21cm.

7-34163 F1215.W78 A.W.C.

The same. New rev. ed. Boston, Page & co., 1912. 4 p. l., v-vi p., 1 l., vii-viii, 492 p. front., plates, port., 2 fold. maps. 21cm. Title within ornamental border.

Bibliography: p. 483-485.

. . . Well arranged, up-to-date, interesting information, obtained by travel and by reading "nearly every prominent work on Mexico and Mexican history," and written in a pleasant, easy style.

12-1770 F1215.W79

Winton, George Beverly, 1861- Mexico to-day; social, political and religious conditions, N. Y., Missionary education movement of the U. S. and Canada, 1913. x, 235 [3] p. plates, 2 port. (incl. front.), maps (1 fold.). 20cm. (Half-title: Forward mission study courses . . .)

Bibliography: p. 215-222.

13-16826 F1215.W82

Wright, Mrs. (**Marie Robinson**), 1866- Picturesque Mexico. Phila., J. B. Lippincott co. [1897]. 445 p. incl. front., illus., ports. 32½x26cm.

"Description of the country as seen by two enthusiastic women, traveling under official guidance, with every facility for seeing the country at its best."

2-4875 F1215.W95

Zayas, Enriques, Rafael de. Les États-Unis Mexicains. Leurs resources naturelles. Leur progrès. Leur situation actuelle. Mexico, Impr. du Ministère de fomento, 1899. 238 p. 23cm.

Ouvrage publié par disposition du Ministère de "fomento" de la colonisation et de l'industrie de la République Méxicaine.

2-4740 F1208.Z4

G.

Means of Communication: Railroads, Roads and Trails, Canals, Inland Waterways, Rivers, Seaports, Posts and Telegraphs and other Public Works.

Anderson, Alex. Dwight. The Tehuantepec inter-ocean railroad; a commercial and statistical review showing its local, national, and international features and advantages N. Y., Chicago, Barnes, 1880. viii [9]-90 p. fold. maps. 22cm.
"... Authorities," p. [85]-90.
6-4964 HE2819.T3A6 E.S.

Baz, Gustavo, 1852- History of the Mexican railway; wealth of Mexico, in the region extending from the Gulf to the capital of the republic, considered in its geological, agricultural, manufacturing and commercial aspect: with scientific, historical and statistical notes, by G. Baz & E. L. Gallo. Trans. into English by George F. Henderson. Mexico, Gallo & co., 1876. 3 p. l., 9-211 p. 32 pl. (incl. ports.), fold. map. 39cm. Title vignette. Added t.-p., engr. (in colors.)
4-15510 F1215.B38

Garay, Jose de, 1801-1858. An account of the Isthmus of Tehuantepec in the republic of Mexico; with proposals for establishing a communication between the Atantic and Pacific oceans, based upon the surveys and reports of a scientific commission, appointed by the projector, Don José de Garay. Lond., Printed by J. D. Smith and co., 1846. viii [9]-128 p. fold. maps. 22cm.
6-3948 TC785.G21 E.S.

Mexico. Dirección general de faros. . . . Estado de la iluminacion y balizamiento de las costas de los Estados Unidos Mexicanos en 30 de junio de 1911. Mexico, Tip. de la Secretaria de comunicaciones y obras publicas, 1912. 65 p., 19 l. plates (part col., part fold). 10 fold. maps, tables (part fold). 23cm.

At head of title: Estados Unidos Mexicanos. Secretaria de comunicaciones y obras publicas.—Sección primera.—Dirección general de faros.

13-23654 VK1028.A5 1912

Mexico. Ministerio de comunicaciones y obras publicas. . . . Album de los ferro-carriles. Año de 1889-1891. México, 1891-93. 3 v. in 2. tables (part fold.) 22cm.

1889 pub. by the "Secretaria de fomento."

1891 has at head of title: Secretaria de comunicaciones y obras publicas.—Seccion segunda.

1889-1891 include "datos generales relativos a los años anteriores, a contar desde el año de 1873."

8-15556 HE2811.A4

Mexico. Ministerio de comunicaciones y obras publicas. . . . Anales de la Secretaria de comunicaciones y obras publicas . . . Mexico, 1902-10. 20 v. iv, 13, plates (part fold.) fold. plans, tables (part fold.) fold. profiles, diagrs. (part fold.) 24cm. quarterly. 1-6, año, enero de 1902—Oct. de 1907, num. 1-24.

Included are "Personal de la Secretaria de comunicaciones y obras publicas," enero de 1904, "Personal de la Direccion general de telegrafos federales y oficinas de su dependencia," enero-abril de 1904, and "Personal de la Direccion general de correos y oficinas de su dependencia," julio de 1904.

11-17453 TA28.A3

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Report year ends June 30.

Report of June 30, 1899, covers the period from July 1, 1890, to June 30, 1899.

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UC315.M6A4 1894

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Contents.—1. pte. Reseña histórica de los ferrocarriles.—2 pte. Itinerario jurisdiccional de los ferrocarriles vigentes en construccion y explotación. Tarifas. Resultados de la explotación y sus diagrammas.—3. pte. Ferrocarriles clasificados en zonas, cuadros estadisticos que indican su construccion, parte comercial y financiera de las compañias y accidentes.

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Index.

Page

Abbot, G. D. 1

Abert, J. J., See U. S. Pres. Message 22

Adams, J. J., Lieut. See Bishop, W. W. 42

Adventures and recollections. Lane, W. P. 47

Adventures in Mexico. Donnavan, C. 43

Adventures of an English Soldier, C. 41

Aguilar y Santillan, R. 76

Alabama volunteer troops. U. S. war dept. 31

Alaman, Lucas, 1792-1853. Historia de Mejico 1. See also Robinson, Mexico 70

Album de los ferrocariles. See Mexico 91

Alcaraz, R. 8

Allen, DeWitt Clinton, 1835- See Hughes, J. T. 36

Allen, G. N. 9

Allen, L. L., Pencillings 40

Almanac. Gen. Taylor's rough and ready 64

Almonte, J. N., 1812-1869. See Robinson, F. 70

Alta California. See Conquest of N. Mexico.

Altitudes. See Hartman, G. W., 45. Campbell, R. 78

Amecameca. See Maxson, H. R. 82

American campaigns 20

American colony, Committee of. See Mexico 84

American commonwealth series. See Royce, J. 37

The American Egypt. Arnold, C. 76

American gift book 9

American guard at Tacubaya. See Smith, R. H. 52

American quarterly register. See Baylies, F. 41

Amozoque. See Hillard, G. St. 59

Ampudia, P. de, 9. See also Robinson, F. 70

Anderson, A. D. Tehuantepec . . . railroad 90

Page

Anderson, R., General, 1805-1871. Port. 40

Anderson, R. An artillery officer 40

ANECDOTES. See The life of Gen. Taylor, 68. Gen. Scott and his staff, 60. Taylor and Fillmore, 68. Gen. Taylor and the Mexican war, 64. Gen. Taylor and his staff, 64. Thorpe, T. B. Taylor anecdote book, 69. The war and its warriors, 32.

Annales of San Francisco. Soulé, F. 7

Arista, M., 1802-1855. See Robinson, F. 70

Arkansas River. See U. S. Engineer dept. 38

Army, Mexico. Brady, A. C. Mexico's fighting equipment, 77 See also Martin, P. F., 81. Mexican year book, 82. Mexico. Ministerio de guerra, 83. Niox, G. L. Armée et marine, in Le Mexique, 84. Pan-American union, 85. Skinner, H. B., 103. Terry, T. P., 86. Types of Mexican army, in Martin, P. F., 81.

Army of occupation, Despatches, U. S. War dept., 30. See also Carleton, J. H., 43: Relic of our war, 49. Thorpe, T. B., 53.
See Hughes, J. T., 35. U. S. Engineer dept. 38

Army of the West. Expedition of.

Army, Scenes and adventures in. Cooke, P. St. G. 79

Arnold, C. The American Egypt 76

Artillery, 2d.—U. S. Company H.—Battery M.—Light Battery A.—See Reilly, J. 49

Artillery corps. See Philadelphia grays. 49

An artilleryman's story. Reilly, J. 49

ARTILLERY officer in Mexican war. Anderson, R. 40

Page

Artillery, Our, in Mexican war. Van Deusen, G. W. 54

Authority by military officers. Davis, J., Civil power and 62

Autobiography of an English soldier in U. S. army. Ballentine, G. 41

Aztec club. Names of original members. See Wilcox, C. M. 32

Backus, E. Brief sketch of battle of Monterey, 40. Details of controversy 41

Baerlein, H. Mexico, the land of unrest 76

Balbontin, M. 9

Balestier, J. N., ed. See Revere, J. W. 36

Ballentine, G. Mexican war 41

Baltimore and Washington volunteers. See Kenly, J. R. 47

Bancroft, H. H. 1, 2, 3, 4

Banditti. See The high private 45

Barbarous Mexico. Turner, J. K. 87

Barra, F. L. de la, see Ponce de Leon, G. 5

Barreiro, A. See Alcaraz, R. 8

Barrett, J. See International bureau of American Republics, 94. Pan-American union 85

Barton, M. Impressions of Mexico 77

Battlefields, Mexican. See Rodenbough, T. F. 50

Battles of Mexico 9

Baylies, F. 9, 41

Baz, G. History of Mexican railway 90

Beacons—Mexico. See Mexico. Direccion 90

Beauregard, P. G. T., 1818-1893. Roman, A. 55

Beauregard's attack of Chapultepec. See U. S. Pres. Message 22

Belknap, Wm. G., 1794-1851. Life. See Gen. Taylor and his staff 64

Bellemare, L. 10, 77

Benham, H. W. Recollections of Mexico 41

Benjamin, Lieut. See Thorpe, T. B. Our army at Monterey 53

Page

Benson, Sergt., 2d Artillery. See Reilly, J. 49

Benton, T. H. Thirty years' view 10. See also Conquest of Santa Fé 34

Biddle, Letters, etc. See U. S. War dept. Messages of Pres. 29

Bigot, R. Le Mexique Moderne 77

Billings, H. See Phelps, W. D. Fore and aft 73

Biographical Sketches. See Frost, Life of Maj. Gen. Z. Taylor, 63 Gen. Scott and his staff, 60. Gen. Taylor and his staff, 64. Life and public services of Gen. Z. Taylor, 64-65. Powell, C. F. Life of Taylor, 66. Robinson, F., 18, 70. Taylor and his generals, 68. Twitchell, R.E., 37. The war and its warriors, 32.

Birt, C. R. See Winter, N. O. 88

Bishop, W. W. Journal of 12 months' campaign 42

Bixby, Wm. K., 1857- See Taylor, Letters 67

Blake, Jacob Edmund (Engineer officer), 1812-1846. Life. See Gen. Taylor and his staff 64

Blichfeldt, E. H. A Mexican journey 77

Bliss, Wm. W. S., 1815-1853. Life. See Gen. Taylor and his staff 64

Blockade. See U. S. war dept. Despatches 50

The "Bloody First." See Robertson, J. B. 50

Boletin de ingenieros. Mexico. See Schulz, E. E. 51

Bonaparte, R. See Le Mexique 84

Bonner, J. Scott's battles in Mexico 42

Bourgois, L. See Le Mexique 84

Boynton, H. V. See Platt, D. Gen. G. H. Thomas 70

Brackenridge, H. M. Mexican letters 10

Brackett, A. G. Gen. Lane's brigade 42

Brackett, A. G. History of U. S. Cavalry 42

Page

Brady, A. C. Mexico's fighting equipment 77
Bragg, Braxton, 1817-1876. Life. See Gen. Taylor and his staff 64
Breakwaters. See Manzanillo breakwater.
A Brilliant national record. Gen. Taylor's life 62
British-owned Railways, Mexico. See Martin, P. F. 81
The broad pennant. Taylor, F. W. 74
Brooks, N. C. Complete history of Mex. war 10
Brown, Jacob, 1788-1846. Life. See Gen. Taylor and his staff, 64. Powell, C. F. Life of Maj. Gen. Taylor 66
Brown. Steamer Major Brown. See Tiden, B. P., jr. 87
Buchanan, J., 1791-1868. See Correspondence.
Buena Vista. See a brilliant national record, 62. Fry, J. R. Life of Gen. Taylor, 63. Howard, O. O. Gen. Z. Taylor, 64. Life and public services of Gen. Z. Taylor, 64-65. The life of Gen. Taylor, the hero, 65. Powell, C. F. Life of Maj. Gen. Taylor, 66. Rives, G. L. The U. S. and Mexico, 6. Carleton, J. H., 43. Gibson, J. W., 45. Grindall, J.J., 45. See also Baylies, F., 9. Benham, H. W., 41. Buhoup, J. W., 42. Kendall, G. W., 47. Reid, S. C., 49. Sketches of the Mexican war, 51. Wilcox, C. M., 32.
Buena Vista, Battle-ground and vicinity. See Fry, J. R. Life of Gen. Taylor 63
Buena Vista, Plan of battle. See Ripley, v. I, 17; Wilcox, 32; Rives, G. L., 6; U. S. Pres. Message 23
Buena Vista. Poem. By Grindall, J. J., 45. By A. Pike. See Rodenbough, T. F. 50
Buena Vista, Taylor at. See Fry, J. R. Life of Gen. Taylor 63
Buhoup, J. W. Narrative of central division 42

Page

Buoys.—Mexico. See Mexico. Dirección 90
Burford, R. Description of a view of of the city of Mexico 78
Burnett, W. B., Colonel. See: The high private 45
Bustamente, Carlos Maria de, 1774-1848. El nuevo Bernal Diaz del Castillo, 11. See also Robinson, F. Mexico, 70.
See Gen. Taylor and his staff 64
Butler, Pierce M., 1798-1847. Life. (Port.) See Wilcox, C. M. 32
Butler, Wm. Orlando, 1793-1880. Life. See Gen. Scott and his staff 60

Caballero, Manuel. See Moralès, V. 84
Cadwalader, George, 1806-1879. Life. See Gen. Scott and his staff 60
See also Philadelphia grays 49
Calderón de la Barra, F. E. I. Life in Mexico 78
California. See also Alta California —Conquest of New Mexico and Cal. — Lower California — Upper California. Bancroft, H. H., History of the Pacific States, 2, 3. Royce, J., 37. See also Frost, J., Life of Maj. Gen. Z. Taylor, 63. Rives, G. L., The U. S. and Mexico. 6. Soulé, F. Annals . . . 7. Hittell, J. S., History, 4. Willard, Mrs. E., 33.
California historical society. Papers. See Jones, W. C. 36
California. How secured. Bancroft, H. H. 3
California, Three years in. Colton, W. 34
California, The U. S. Consulate in 4
A campaign in Mexico. Scribner, B. F. 51
Campaign of Gen. Scott. See Semmes, R. Service afloat 74
Campaign sketches 13
Campbell, R. Campbell's . . . guide 78
Camp life of a volunteer. Scribner, B. F. 51
Cape Horn, Account of voyage around. See Revere, J. W., A tour 36

Page

"Captain of volunteers." See Conquest of Santa Fé 34
Capture of Monterey. See U. S. War dept. Correspondence with Gen. Taylor 27
Capture of Vera Cruz 43
Carleton, J. H. Battle of Buena Vista 43
Carpenter, W. W. Travel and adventures 43
Carson, Christopher (called Kit Carson), 1809-1868. Life. See Gen. Scott and his staff 60
Carson, W. E. Mexico, the wonderland 78
Casey, Silas, Capt., 1807-1882, 2d Infantry, storming Chapultepec. See Reilly, J. 49
Cass, L., 1782-1866. War with Mexico 11
Castillo, J. M., See Alcaraz, R. 8
The castle of San Juan Ulloa, . . . Conner, P. S. P. 71
Causes of Mexican war. See U. S. Congress 20
Cavalry. See also Dragoons.
  See Lane, W. B., 47. Frontier service, 44.
Cavalry, History of the U. S. Brackett, A. G. 42
Central America and its problems. Palmer, F. 85
Central America and Mexico. Fortier, A. 4
Central division, Mexican war. See Buhoup, J. W. 42
Central Mexico, Map, showing route of army. See Life and public services of Gen. Z. Taylor 64-65
Central Railway—Mexico. See Martin, P. F. 81
Cerro Gordo. See Hillard, G. St., 59. Kendall, G. W., 47. McSherry, R. El puchero, 48. Reilly, J., 49. Ripley, v. 2, 17. Rives, G. L., 6. U. S. War dept. Letter, 27. Wheeler, J. B., 32.
Cerro Gordo, Battleground of. See Anderson, R., 40. Ripley, R. S., v. 2, 17. Rives, G. L., 6. Wilcox, C. M., 32.

Page

Cerro Gordo, Mexican lines of defense See U. S. Pres. Message 23
Chalco Route, Memoranda given by Lee to Mason, Concerning. See Ripley, R. S., v. 2, appendix 17
Chapultepec and the gates of Mexico. (Map.) See Rives, G .L., 6. Wilcox, C. M. 32
Chapultepec, Battle of. See Anderson, R., 40. Hillard, G. St., 59. Reilly, J., 49. Rives, G. L., 6. U. S. Pres. Message 23
Chapultepec, Fall of. See U. S. Pres. Message 23
Chapultepec, Storming of. See Kendall, G. W., 47. Ripley, R. S., v. 2, 17. Wilcox, C. M., 32.
Chautauquan magazine. See Blichfeldt, E. H. 77
Chihuahua, Army of. See Buhoup, J. W. 42
Chihuahua, Capture of. Hughes, J. T. 35
Chihuahua, March upon. See Hughes, J. T. 35
Chihuahua and Vera Cruz. See Rives, G. L. 6
Childs, Thomas, 1796-1853. Life. See Gen. Scott and his staff 60
Cholula, Pyramid of. See Anderson, R. 40
Churubusco, Battle at. See Hopkins, G. T., 46. Kendall, G. W., 47. Ripley, R. S., v. 2, 17. Rives, G. L., 6. U. S. Pres. Message, 23. Wilcox, C. M., 32.
Churubusco (map). See Rives, G. L. 6
A citizen's appeal 19
Civil power and authority by military officers. Davis, J. 62
Claiborne, J. F. H. Life of J. A. Quitman 60
Claiborne, Thomas. See Frontier service 44
Claretie, J. See Le Mexique 84
Clay, Henry, jr., 1811-1847. Life. See Gen. Taylor and his staff 64
Clifford, Nathan, 1803-'81. See U. S.

Page

War dept. Message, 27-28. See also under Correspondence.

Climate, Mexico. See Campbell, R. 78. Pan-American union, 85. Skinner, H. B., 86.

Coahuila. See Hughes, J. T. 35

Coincidences of the conquests of Mexico 11

Colburn's united service magazine. See Ballantine, G., 41. A general's orderly, 45.

Cole, J. R. Life and public services of W. S. Hancock 56

Colima. See Oswald, F. L. Summerland sketches 85

Colton, W. Three years in Cal. 34

The coming Mexico. Goodrich, J. K. 80

Communications, Means of, Mexico. See also Public works.
See The Mexican year book, 82. Le Mexique, 84. Moore, H. Railway guide, 92. U. S. Bureau of statistics, 93.

Complete history of the late Mexican war 11

Concise history of Mormon Battalion. Tyler, D. 53

Conditions in the Republic of Mexico 78

Conner, David, ca. 1792-1856. Conner, P. S. P. The Home squadron, 71. Letters, etc., see U. S. War dept. Messages of Pres., 29. Orders issued by him. See Temple, W. G., 52. Wilcox, C. M., 32.

Conner, P. S. P. The castle of San Juan Ulloa, 71. The Home Squadron, 71.

Connelley, Wm. Elsey, 1855- editor. See Hughes, J. T., 36.

Conquest of New Mexico and California, p. 34-39. See also Bancroft, H. H., 2-3. Rodenbough, T. F., 50.

Conquest of Santa Fé 34

Conrad, D. H. Cerro Gordo.—Siege of Vera Cruz. See McSherry, R. El puchero, 48.

Conrad, R. T. A sketch of the life of Gen. Taylor. See Fry, J. R. 63

Page

Constitution of California. See Colton, W. 34

Constitutionalists. See Conditions in the Republic of Mexico 78

Consulates, American, in Mexico. See Moore, H. 92

Consulates, Mexican, in U. S. See Moore, H. 92

Contreras, Battle of. (Called Battle of Padierna, by Mexicans.) See Hillard, G. St., 59. Kendall, G. W., 47. Rives, G. L., 6. U. S. Pres. Message, 23

Contreras and Churubusco (Map). See Rives, G. L., 6. Ripley, R. S., 17 (v. 2). Wilcox, C. M., 32.

Contributions, Military, in Mexico. See U. S. war dept. 29

Cooke, P. St. G., Conquest of New Mexico, 34. Report of his march, 35. Scenes and adventures in the army, 79. See also U. S. Engineer dept., 38.

Coppée, H. Coincidences, 11. General Thomas, 69. Grant and his campaign, 56. Life and services of Grant, 56. See Reilly, J., 49. See also U. S. Pres. Message, 23.

"Corporal of the guard." See the high private, 45

Corpus Christi. See Thorpe, T. B. Our army on the Rio Grande 53

Correspondence between Sec'y of War and Gen. Scott. U. S. War dept. 26

Correspondence between Sec'y of War and generals 24

Correspondence, Buchanan, Slidell, Trist, Clifford, Sevier. U. S. War dept. 27, 28

Correspondence, War with Mexico (Complete compilation). U. S. War dept. Messages of Pres. 29

Correspondence with Gen. Taylor. U. S. War dept. 26

Corthell, E. L. Advantages of the

Page

Fifty years in camp and field. Hitchcock, E. A. 58
Flandreau, C. M. Viva Mexico! 79
Forced contributions. U. S. War dept. 28
Fore and aft. Phelps, W. D. 73
Foreign relations, Mexico. See The Mexican year book, 97. Le Mexique 84
Fornaro, C. de. Diaz, czar of Mexico 55
Forney, J. W. Life of Hancock 57
Fort Harrison. See Fry, J. R. Life of Gen. Taylor 63
Fort Jessup to Corpus Christi. See Relic 49
Forts. See Jamieson, M. 46
Fortier, A. Central America and Mexico 4
Foster, John Gray, Engineers, 1823-1874. Commended by Magruder. See U. S. Pres. Message, 22. Wilcox, C. M., 32.
Foville, A. de. See Le Mexique 84
Franklin, Lieut. See U. S. Pres. Message 22
Fraser's magazine for town and country. See Sketches of Mexican war 51
Frémont, John Chas.,1813-1890. Life. See Gen. Scott and his staff 60
See also Cooke, P. St. G. Conquest of New Mexico 34
French, S. G. Two wars 12
From empire to republic. Noll, A. H. 5
From everglade to cañon. Rodenbough, T. F. 50
Frontier service 44
Frost, F. J. T. See Arnold, C. 76
Frost, J. The Mexican war, 12. Pictorial history of Mexico, 12. Life of Maj. Gen. Taylor, 63.
Fry, J. R. Life of Gen. Taylor 63
Furber, G. C. The twelve months volteer, 44. See also Young, P. 7

Gadow, H. F. Through modern Mexico 80

Page

Gaines, Edmund Pendleton, 1777-1849. Life. See Gen. Taylor and his staff, 64. See also Taylor, Z. Gen. Taylor's letters, 67. Gaines correspondence. U. S. War dept.,30
Gallatin, A. Peace with Mexico 12
Gallo, E. L. See Baz, G. 90
Garay, J. de. An account of Isthmus of Tehuantepec in republic of Mexico 90
Garland, John, 1792-1861. See Reilly, J. 49
Gardner John Lane, 1793-1869. See Reilly, J. 49
Garnett, Robt. Selden, 1820-1861. Life. See Gen. Taylor and his staff 64
General order no. 111,issued by Scott. See Wheeler, J. B., 32. General order no. 376, U. S. war dept., 29. General order no. 279. See Ripley, R. S., v. 2, 17.
A general's orderly 45
General Scott and his staff 60
General Taylor and his staff 64
General Taylor and the Mexican war 64
General Taylor and the Mexican war. See Quisenberry, A. C. History by illustration 66
General Taylor's rough and ready almanac 64
General Thomas. Coppée, H. 69
George, I. Heroes and incidents of Mexican war 12
Gibson, J. W. Letter descriptive of battle of Buena Vista 45
Giddings, L. Sketches of campaign in northern Mexico 45
Gihon, J. H. See Soulé, F. 7
Gila River. See U. S. Engineer dept. 38
Gillespie, Robt. A. 1846. Life. See Gen. Taylor and his staff 64
Gillpatrick, O. W. The man who likes Mexico 80
A glimpse at life in camp. See Scribner, E. B. Camp life 51
Godoy, J. F. Porfirio Diaz 55
Gomez, Farias, Valentin, 1781-1858. See Robinson, F. Mexico 70
Gomot, H. See Le Mexique 84

Page

Gooch, Mrs. See Iglehart, Mrs. F. C. G.

Goodrich, F. E. Life and public services of W. S. Hancock ---------- 57

Goodrich, J. K. The coming Mexico ---------- 80

Gran Quivira region, Survey of. See U. S. Engineer dept. ---------- 38

Grant, U. S., pres. U. S. 1822-1885. Life and services, Coppée, H., 56. Grant, U. S., Personal Memoirs, 56. Grant and his campaign, Coppée, H., 56. See also Hudnut, J. M., Commanders, 70. Portrait, see Wilcox, C.M., 32.

Gréard, O. See Le Mexique ------- 84

Great commanders, ed. by J. G. Wilson. See Coppée, H. Gen. Thomas, 69. Howard, O. O., Gen. Z. Taylor, 64. Mahan, A. T., Admiral Farragut, 73. Michie, P. S., Gen. McClellan, 60. Soley, J. R., Admiral Porter, 74. Walker, F. A., Gen. Hancock, 57. Wright, M. J. Gen. Scott, 62.

Green, J. St. The war with Mexico- 12

Griffis, W. E. Matthew Calbraith Perry ---------- 72

Grindall, J. J. Battle of Buena Vista 45

Grone, C. von Briefe über Nord-Amerika ---------- 13

Guadalupe Hidalgo, Treaty of. See U. S. State dept., 25. See also Rives, G. L., 6. Wilcox, C. M., 32.

Guanajuato. See Kendall, J. S., Seven Mexican cities ---------- 81

Guanajuato, Jalpo Dam. See Martin, P. F. ---------- 81

Guerrillas. See The high private -- 45

Gulf coasts. See Revere, J. W.----- 36

Gulf squadron. See Taylor, F. W. The broad pennant ---------- 74

Gutierrez de Lara, L. See U. S. Congress ---------- 88

Halleck, H. W. Elements of military art ---------- 13

Haller, A. See Le Mexique------- 84

Page

Hamilton, J. (Review) ---------- 13

Hancock, ''the superb.'' Denison, C. W. ---------- 57

Hancock, W. S., 1824-1886. (Life) Walker, F. A., 57. Cole, J. R., 56. Norton, F. H., 57. Goodrich, F. E. 57.

Harbors, Mexico. See Campbell, R., 78. Martin, P. F., 81. The Mexican year book, 82. Skinner, H. B. Mexico in miniature, 86.

Hardcastle, E. L., 1824-1899. See U. S. War dept. Report of Sec'y of war, 31. Map of Valley of Mexico. See U. S. Pres. Message, 23.

Hardee, Wm. J., Capt., 1819-1873.

Disembarking horses. See U. S. Pres. Message, 22. Wilcox, C. M., 32.

Hardie, F. H. The Mexican war---- 13

Hardin, John J., Col.,1810-1847. Life. See Gen. Taylor and his staff---- 64

Harney, Wm. Selby, 1800-1889. Life. See Gen. Scott and his staff, 60. See also Reilly, J.---------- 49

Harper's new monthly. See Bonner, J. ---------- 42

Harrison, Fort. See Life and public services of Gen. Z. Taylor---- 65

Hart, Patrick, Sergt., 2d Artillery. See Reilly, J. ---------- 49

Hartman, G. W. A private's own journal ---------- 45

Hays, John Coffee, 1818-1861. See Gen. Taylor and his staff, 64. Reid, S. C., Scouting expeditions ------- 49

Hays, Wm., 1819-1875. (Battery A) See Reilly, J.---------- 49

Heights. See Altitudes.

Henderson, G. F. Translator. See Baz, G.

Henderson, G. F. R. Stonewall Jackson ---------- 58

Henrie, Dan Drake,*1849. Life. See Gen. Taylor and his staff---------- 64

Henry, W. S. Campaign sketches of war ---------- 13

Herbert, G. B. See Denison, C. W. Hancock ---------- 57

Heroes and incidents of Mexican war.

Page

George, I. 12

Herrera, José Joaquin de, 1792-1854. See Robinson, F. Mexico 70

Hidalgo y Costilla, Miguel, 1753-1811 See Robinson, F. Mexico 70

The high private 45

Hillard, G. St. Life and campaigns of G. B. McClellan 59

Historical magazine. See Backus, E. 40, 41. Deas, G., 43.

History of the Mexican railway. Baz, G. 90

History of the war between the U. S. and Mexico 14

History of U. S. Cavalry. Brackett, A. G. 42

History of the U. S. Navy. Maclay, E. St. 72

History by illustration. Quisenberry, A. C. 66

History of Texas 13

Hitchcock, E. A. Fifty years in camp and field 58

Hittell, J. S. History of city of San Francisco 4

Hoeck's guide to Mexico. See Maxson, H. F. 82

The Home Squadron under Commodore Conner, P. S. P. 71

Hopkins, G. T. San Patricio battalion 46

Hostilities by Mexico. U. S. State dept., 25. U. S. War dept. Messages of Pres., 29.

Houston, Sam., 1793-1863. See Conquest of Santa Fé 34

How California was secured. Bancroft, H. H. 3

Howard, O. O. Gen. Z. Taylor 64

Howard, Oliver Otis, 1830-1909. See Hudnut, J. M. Commanders 70

Hudnut, J. M. Commanders of the Army of the Tennessee 70

Huerta, Victoriano, prov. pres. Mexico. See Conditions in the Republic of Mexico, 78. See also Baerlein, H. 76

Hughes, George Wurtz (Top. Engineers), 1806-1870. Letter from. See Kenly, J. R., 47. March under Wool from San Antonio. See U. S. Engineer dept. Report, 54.

Hughes, J. T. Doniphan's expedition 35, 36

Humantla. See Reilly, J. 49

Hume, M. See Enock, C. R.

Hungerford, D. E. See Cowan, J. E.

Hunt, Henry Jackson, 1819- See Reilly, J. 49

Hurlbert, W. H. Gen. McClellan 46

Hutchinson, E. See Battles of Mexico 9

Iglehart, Mrs. F. C. G. Face to face with the Mexicans 80

Iglesias, José Maria, 1823-1891. See Alcaraz, R. 8

Illinois volunteers. See Bishop, W. W. 42

Illustrated life of Gen. W. Scott 61

Impressions of Mexico. Barton, M. 77

Incident in war of U. S. with Mexico. McWhorter, G. C. 37

Indiana brigade. See Smith, Isaac 52

Infantry, Third. See Hitchcock, E. A. 58

Inge, Zebulon Mont. Pike, 1815-'46. Life. See Gen. Taylor and his staff 64

Ingersoll, Chas. Jared, 1782-1862. See U. S. Congress 20

Intercepted letters, A series of. See Smith, Robt. H. 52

International bureau of American republics. Mexico 80
See also Pan-American union.

An international railway to the city of Mexico. Reavis, L. U. 92

Invasion by Mexico. See U. S. State dept., 25. U. S. War dept. Messages of Pres., 29.

Iturbide, Augustin de., 1783-1824. See Robinson, F. Mexico 70

Iztaccihuatl, Mount. See Anderson, R. 40

Jackson, Thomas Jonathan (called Stonewall Jackson), 1824-1863. Life. See Henderson, G. F. R., 58. Randolph, S. N., 58. See also Benton, T. H., Thirty years' view, 10.

Page
scription. See Encyclopædia Brit., ed. 11, v. 15, p. 131; Lippincott's Complete pronouncing gazetteer, 1906, p. 899. Other references: Baerlein, H.,76 (p. 57, 98-99, 363). Wilcox, C. M., 32 (p. 23-24, 268-271, 275, 276, 284, 285, 287, 292, 294, 295, 297, 299, 303, 304, 305, 313, 317, 318.)
Jalapa Road. See Wilcox, C. M. 32
Jalisco. See Lumholtz, K. S. Unknown Mexico, 81. Oswald, F. L. Summerland sketches, 85.
Jalpo Dam, state of Guanajuato. See Martin, P. F. 81
Jamieson, M. Journal and notes 46
Jaurata, Priest. See The high private 45
Jay, W. Review of the causes 14
Jenkins, J. St. History of the war 14
Jenkins, J. St. Extrait de l'histoire 14
Johnson, H. V. The war with Mexico 14
Johnson, R. W. Memoir of Maj. Gen. G. H. Thomas 69
Johnston, Albert Sidney, 1803-1862. Life. Johnston, W. P. 58
Johnston, Capt., Jos. E., Top. Engineers ,wounded. See Wilcox, C. M. 32
Johnston, W. P. Life of Gen. A. S. Johnston 58
Jones, C. C. The life and services of Commodore J. Tattnall 72
Jones, Roger, 1789-1852. Life. See Scott and his staff 60
Jones, W. C. First phase of conquest of California 36
Journal of a private. See Furber, G. C. 44
Journal of W. H. Richardson, a private soldier. Richardson, W. H. 50
Journal and notes of a campaign in Mexico. Jamieson, M. 46

Kane, T. L. The Mormons. See Tyler, D. 53
Kansas City, Mexico and Orient Railway. See Martin, P. F. 81

Page
Kearny, Philip, 1815-1861. Personal and military history. De Peyster, J.W.,59 See also Gen. Scott and his staff, 60. U. S. Engineer dept. Notes . . . 38.
Kearny's march from New Mexico to to California. See Hughes, J. T., 35-36. U. S. Engineer dept. Notes of military recon., 38.
Keel and saddle. Revere, J. M. 73
Kelsey, R. W. The U. S. Consulate in California 4-5
Kendall, G. W. War between Mexico and U. S. 47
Kendall, J. S. Seven Mexican cities 81
Kenly, J. R. Memoirs of a Maryland volunteer 47
Kentucky cavalry. See Encarnación 44
Kentucky historical series. See Quisenberry, A. C. History by illustration 66
Kentucky troops in Mexican war. See Quisenberry, A. C. 66
Kentucky volunteers in Mexican war. See Quisenberry A. C. 66
Ker, Croghan, 2d Dragoons. See Reilly, J. 49
Kernan, F. J. See U. S. War dept. Claims 88
Killed. See U. S. Navy dept. Annual report 74
Killed, . . . See also Wounded, . . . See Gen. Taylor and the Mexican war, 64. Life and public services of Gen. Z. Taylor, 65. Reid, S. C., 49. U. S. War dept. Report, 32.
King's Bridge. See Reilly, J. 49
Kirkham, St. D. Mexican trails 81
Knickerbocker, or, New York Monthly magazine. See Capture of Vera Cruz 43
Krantz, C. See Le Mexique 84

Ladd, H. O. History of war with Mexico 15
Lagrave, M. See Le Mexique 84
Lakes, Mexico. See Campbell, R., 78. Skinner, H. B., 86.
Landing of expedition against Vera

Page

Cruz. Lott, W. C., 48. Temple, W. G., 52.

Lane, Joseph, 1801-1881. Life. See Gen. Scott and his staff 60

Lane, W. B. History of the Mexican war, 15. Our cavalry in Mexico, 47. Regiment of mounted riflemen, 47.

Lane, W. P. Adventures and recollections 47

Lane’s Brigade. Brackett, A. G. 42

Larkin, T. O. Larkin papers, 36. See also Kelsey, R. W., 4-5.

Last leaves of American history. Willard, Mrs. E. 33

Late victories in Mexico 48

Launay, L. de. See Le Mexique 84

Lawton, E. A. See Anderson, R. 40

Leaves from the life of an old sailor. See Phelps, W. D. Fore and aft 73

Lee, Robt. Edward, 1807-1870. Memoirs. Long, L., 59. Popular life. Mason, E. V., 59. See also Frontier life, 44. Reilly, J., 49. See Wilcox, C. M., 32.

Lee wounded at Chapultepec. See Mason, E. V. Popular life 59

Lemcke, H. Mexicko: das land und seine leute 81

Leroy-Beaulieu, P. See Le Mexique 84

Letters of W. Scott. See Scott, W. Letters, 61. See also Correspondence.

Letters of Gen. Taylor. See Taylor, Z., 67. See Life and public services of Gen. Taylor, 64-65. Thorpe, T. B. The Taylor anecdote book, 69. See also Correspondence . . .

Levasseur, W. See Le Mexique au début 84

Levying of duties. U. S. War dept. 29

Life in Mexico. Calderon de la Barca, F. E. I. 78

Life and services of Gen. U. S. Grant. Coppée, H. 56

Life and military services of W. S. Hancock. Forney, J. W. 57

Life of Gen. W. Scott, commander-in-chief 61

Page

Life of Maj. Gen. Taylor. Powell, C. F. 66

The life of Gen. Taylor, the hero 65

Life and public services of Gen. Z. Taylor 64, 65

Lighthouses — Mexico. See Mexico. Dirección 90

Lincoln, George, d. 1847. Life. See Gen. Taylor and his staff, 64. See also Allen, G. N. Mexican treacheries, 9.

Linnard, Thomas B., 1810-1851. See U. S. Pres. Message 23

Lists of officers who marched with army under Scott. U. S. Adjt. gen. office 53-54

Littell’s living age. See Late victories 48

Livermore, A. A. The war with Mexico reviewed 15

Lobos, Island of. See Moore, H. J. Scott’s campaign in Mexico 61

Logan, John Alex., 1826-1886. See Hudnut, J. M., Commanders 70

Lombard, Albert. See The high private 45

Long, A. L. Memoirs of R. E. Lee 59

Los Angeles, Battle of. See U. S. Engineer dept., 38. U. S. Pres. Message, 23.

Lossing, Benson, J. See Sumpter, A. 67

Lott, W. C. Landing of expedition against Vera Cruz 48

Lower California. See Revere, J. W. 36

Lumholtz, K. S. Unknown Mexico, 81. New trails in Mexico, 81.

Lytle, James T. The Ranger’s song. See Reid, S. C. 49

McClellan, George Brinton, 1826-1885. Life and campaigns. Hillard, G. St., 59. Hurlbert, W. H., 46. Michie, P. S., 60. See also Wilcox, C. M., 32.

McClellan commended by Magruder. See U. S. Pres. Message 22

McCoy, Frank, Capt. See Hopkins, G. T. 46

McCulloch, Ben., 1811-1862. See Gen.

Page

Taylor and his staff, 64. Reid, S. C., Scouting expeditions, 49.

McCulloch's Texas rangers. See Reid, S. C., 49

McKay, W. See Cowan, J. E. 11

McKenzie, Sam., Capt., 1st Division, 2d Artillery, d. 1847, killed at Chapultepec. See Reilly, J. 49

Maclay, E. St. History of the U. S. navy 72

McPherson, J. B. See Hudnut, J. M., Commanders 70

McPherson, J. D., Evolution of the myth 15

McSherry, R. El puchero, 48. A Mexican campaign sketch, 48.

McWhorter, G. C. Incident in war of U. S. with Mexico 37

Madero, Francisco I., pres. Mexico, 1873-1893. See Baerlein, H., 76. Conditions in the Republic of Mexico, 78.

Madero sin máscara. Aguilar y Santillán, R. 76

Magruder, John Bankhead, 1811-1871 Commending Foster and McClellan. See U. S. Pres. Message 22

Mahan, A. T. Admiral Farragut 73

The maker of Modern Mexico. Tweedie, E. B. H. 56

The man who likes Mexico. Gillpatrick, O. W. 80

Manzanillo breakwater. See Martin, P. F. 81

Manzanillo harbor. Plan of. See Martin, P. F. 81

Manzanillo, Port of. See Martin, P. F. 81

Mansfield, E. D. Life of Gen. Scott, 61. See also Illustrated life 61

Mansfield, E. D. Mexican war 15

Mansfield, Jos. King Fenno, Engineers, 1803-1862. Life. See Gen. Taylor and his staff, 64. Report, see U. S. War dept. Correspondence 27.

Map of operations in Texas. See U. S. Engineer dept. Report of Sec'y of war 54

Page

March from Puebla upon Mexico. See U. S. Adjt. Gen.'s office. Lists 54

March from Santa Fé to San Diego. Cooke, P. St. G. 35

March of Kentucky cavalry from Louisville to the Rio Grande. See Encarnación prisoners. 44

March of U. S. troops from San Antonio to Saltillo. Baylies, F. 41

March of U. S. troops under Gen. Wool. Baylies, F. 41

March to Mexico. See Hillard, G. St. 59

March under Wool from San Antonio de Bexar to Saltillo. Hughes, G. W. See U. S. Engineer dept. Report 54

March upon Chihuahua and Durango. See Hughes, J. T. 35-36

Marches. See Rodenbough, T. F. 50

Marcy, Wm. Learned, 1786-1857. Reprimand to Gen. Taylor. See Taylor, Z. Gen. Taylor's letters, 67. Scott, W., Letters of Gen. Scott and Sec'y Marcy, 61.

Mariano Paredes, see Paredes.

Marines. See McSherry, R. El puchero 48

Martin, P. F. Mexico of the 20th century 81

Maryland volunteers. See Kenly, J. R. 47

Mason, E. V. Popular life of Gen. R. E. Lee 59

Mason, James L., Capt., Engineers, 1817-1853. (Map drawn by him.) See U. S. Pres. Message, 23. See also Reilly, J., 49.

Matamoras. See Relic of our war 49
Thorpe, T. B. Our army at Monterey, 53. Thorpe, T. B. Our army on the Rio Grande, 53.

Matamoras to Point Isabel (Map). See Rives, G. L., 6.

Maury, Dabny H., Lieut., 1824-1900. See Reilly, J. 49

Maxson, H. R. A practical up-to-date guide to Mexico city 82

May, Chas. A., 1818-1847. Life. See Gen. Taylor and his staff 64

Page

May's dragoons charging the enemy's batteries. See Fry, J. R. Life of Gen. Taylor 63
Mayer, B. History of the war . . . 16 Mexico as it was . . . 82.
Meade, George Gordon, 1815-'72. Plan of defenses of Monterey, drawn by him. See Reid, S. C., 49. See also Relic of our war, 49.
Memoir of tour to northern Mexico. Wislizenus, A. 37
Memoirs of Lieut. Gen. Scott, by himself. See Scott, W. 61
Merida. See Kendall, J. S. Seven Mexican cities 81
The Mexican boundary from Texas to California (map). See Rives, G. L. The U. S. and Mexico. 6
A Mexican campaign sketch. McSherry, R. 48
Mexican Central Railroad. See Torre, J. de la 93
Mexican cities, Seven. Kendall, J. S. 81
Mexican cities. See Skinner, H. B., 86. Steele, J. W., 86.
Mexican coasts. See Lighthouses.
Mexican defenses. See Grant, U. S. Personal memoirs 56
Mexican Gulf, War in the. See Maclay, E. St. 72
Mexican Indians. See Kirkham, St. D. Mexican trails 81
Mexican invasion. See Rives, G. L. 6
A Mexican journey. Blichfeldt, E. H. 77
Mexican letters 10
Mexican market, Scene in. See Anderson, R. 40
Mexican people, History of. Bancroft, H. H. 4
Mexican railway, History of. Baz, G. 90
Mexican revolution, 1910. See Baerlein, H. 76
Mexican situation. See Mexico (City) Committee 84
Mexican trails. Kirkham, St. D. 81
Mexican treacheries. Allen, G. N. 9
Mexican war, 1846-1848. See p. 8- 33 See also Conquest of California and New Mexico, p. 34-39.—Special campaigns and battles, etc., p. 40-54.—Biographical material, p. 55 - 70. The Navy, p. 71-74. See also Benton, T. H. Thirty years' view, 10.
Mexican war correspondence. See Correspondence.
Mexican war, Military reports. U. S. War dept. 30
Mexican war. Notes on the. Oswandel, J. J. 48
Mexican war series. See Stratemeyer, E. 67
Mexican war, Sketches of 51
Mexican war veterans 17
Mexican water carriers. See Anderson, R. 40
Mexican year book 82
Mexico. Dirección general de faros. Estado de la iluminacion 90
Mexico, Map of. See Martin, P. F., 81. Rives, G. L., 6.
Mexico. Ministerio de comunicaciones y obras publicas 91-92
Mexico. Ministerio de guerra y marina 83
Mexico. See also Central Mexico. Cities and towns. See Mexican cities. Foreign relations. See Estournelles de Constant, P. H. B. d', in Le Mexique, 84. Mexican year book, 82.
Mexico. See also Palmer, F. Central America 101
Mexico al dia. Dollero, A. 79
Mexico and her military chieftains. Robinson, F. 70
Mexico and the U. S. Abbot, G. D. 1
Mexico, Army. See Army, Mexico.
Mexico as it was and as it is. Mayer, B. 82
Mexico, The coming. Goodrich, J. K. 80
Mexico, Conditions in the Republic of 78
Mexico, Defense. See The Mexican year book, 1908 82
Mexico, Diary of a trip to. Moler, A. B. 84
Mexico's fighting equipment, Brady, A. C. 77
Mexico, Guides. See Campbell, R. 78

Page
Lemcke, H., 81. Steele, J. W., 86. Terry, T. P., 87.
Mexico, History of. See p. 1-7.
Mexico in miniature. Skinner, H. B. 86
Mexico, Insurrection. See U. S. War dept. Claims. 88
Mexico. International bureau of American republics 80
Mexico, its ancient and modern civilization. Enock, C. R. 79
Mexico, the land of unrest. Baerlein, H. 76
Mexiko: das land und seine leute. Lemcke, H. 81
Mexico, Life in. Calderon de la Barca, F. E. I. 78
Mexico, Navy. See Navy, Mexico.
Mexico, Northern. Wislizenus, A. 37
Mexico of the 20th century. Martin, P. F. 81
Mexico, past, present, future. Tyler, R. E. 87
Mexico. Persecution of Mexican citizens. See U. S. Congress 88
Mexico, Railroads. See Railroads, Mexico.
Mexico. Sketches of the war in northern Mexico 52
Mexico to-day. Winton, G. B. 89
Mexico, Valley of. See The Valley of Mexico.
Mexico, the wonderland of the South. Carson, W. E. 78
Mexico (City). See Blichfeldt, E. H., 77. Burford, R. Description of a view, 78. Campbell, R., 78. Kendall, J. S., 81. Maxson, H. R., 82.
Mexico, City of. Attack of. See U. S. Pres. Message 22
Mexico City. Capture of. See Anderson, R., 40. Rives, G. L., 6. Taylor, F. W. The broad pennant, 74.
Mexico (City). Committee of American colony. Facts submitted 84
Mexico (City). Distances from Vera Cruz to. See Hartman, G. W. 45
Mexico City. Surrender of. See Sumpter, A. 67

Page
Le Mexique au début de xxe siecle 84
Le Mexique moderne. Bigot, R. 77
Michie, P. S. General McClellan 60
Michoacan, The Tarascos of. See Lumholtz, K. S. Unknown Mexico 81
Military contributions in Mexico. See U. S. War dept. 29
Military forces employed in Mexican war 20
Military instruction, Mexico. See Martin, P. F. 81
Military occupation of New Mexico. Twitchell, R. E. 37
Military reconnaissance from Ft. Leavenworth to San Diego. U. S. Engineer dept. 38
Military reports from commanders of army. U. S. War dept. 30
Military service institution of the U. S. Journal. See Reilly, J., 49. Relic of our war, 49. Lott, W. C., 48. Van Deusen, G. W., 54.
Military transportation, Mexico. Mexico. Ministerio de comunicaciones y obras publicas. Reglamento 92
Milligan, J. F. See Grindall, J. J. 45
Minor wars of the U. S. See Ladd, H. O. 15
Missing lieutenants. See U. S. War Dept. Despatches from Taylor 27
Mitla. See Blichfeldt, E. H. 77
A mixed dish from Mexico. See McSherry, R. El puchero 48
Moler, A. B. Mexico 84
Molino del Rey, El. Battle of. See Anderson, R., 40. Kendall, G. W., 47. Reilly, J., 49. Rives, G. L., 6. Ripley, R. S., v. 2, 17. Wilcox, C. M., 32.
Molino del Rey, Chapultepec in distance. See Denison, C. W. Hancock 57
Monterey, and its approaches (map). See Grant, U. S. Personal memoirs 56
Monterey, Battle of. Backus, E., 40-41. A brilliant national record, 62. Carpenter, W. W., 43. See also Fry, J. R., 63. Howard, O. O., 64. Kendall, G. W., 47. Life and pub-

Page

lic services of Gen. Taylor, 64-65. Life of Gen. Taylor, 65. Powell, C. F., Life of Maj. Gen. Taylor, 66. Reid, S. C., 49. Rives, G. L., 6. See also Map in Rives, G. L., 6.

Monterey, Defenses of. See Fry, J. R., 63. Reid, S. C., 49. (See also plan by G. Meade, in Reid, S. C.), 49. Ripley, R. S., v. 1, 17. Wilcox, C. M., 32.

Monterey. Our army at. Thorpe, T. B., 53

Monterey, Storming of. See Reid, S. C. 49

Montgomery, H. Life of Maj. Gen. Z. Taylor 66

Moody, L. History of the Mexican war 16

Moore, H. Railway guide 92

Moore, H. J. Scott's campaign in Mexico 61

Morales, V. El Señor Root in Mexico 84

Morehead, Chas. R., 1838- Personal recollections. See Hughes, J. T. 36

Morelos y Pavon, José Maria, 1765-1815. See Robinson, F. 70

Mormon Battalion. See Cooke, P. St. G. Conquest of New Mexico 34

Mormon battalion and first wagon road over . . . desert. See Tyler, D. 53

Mormon battalion, History of. Tyler, D. 53

Moses, B. The railway revolution in Mexico 92

Moses, J. T. To-day in the land of to-morrow 85

Mosquito Flotilla. See Jones, C. C. 72

Mount Iztaccihuatl. See Anderson, R. 40

Mount Orizaba. See Anderson, R. 40

Mountains, Mexico. See Campbell, R. 78

Mounted company of artillery. See A general's orderly 45

Mounted riflemen. See Frontier sketches, 44. Lane, W. B. Regiment, 47. Lane, W. P., Adventures, 47. Reid, S. C., 49. Reilly, J., 49.

Muñoz, M. See Alcaraz, R. 8

Munroe, John. d. 1861. Life. See Gen. Taylor and his staff 64

Page

Murphy, C. J. Reminiscences, 16. See also Cowan, J. E., 11.

Navajos. Doniphan's campaign against. See Hughes, J. T. 35-36

Naval and marine service. Number of persons employed in Mexican war U. S. Navy dept. 74

Naval battery, Work of. See Maclay, E. St. 72

Naval forces. See U. S. Pres. Message. (House doc.) 24

Naval operations. Soley, J. R. Admiral Porter, 74. U. S. Navy dept. Annual report, 74. See also Conner, P. S. P., 71. Dupont, S. F., 71. Farragut, L., 71. Griffis, W. E. 72. Jones, C. C., 72. Mahan, E. T. 73. Parker, W. H., 73. Phelps, W. D., 73. Revere, J. W., 73. Rowan, St. C., 73. Skinner, H. B., 86. Taylor, F. W., 74. U. S. Navy dept. Number . . . 74.

Navy, Mexico. See Martin, P. F., 81. Mexican year book, 82. Mexico. Ministerio de guerra y marina. Memoria, 83. Niox, G. L. Armée et marine, in Le Mexique, 84. Pan-American union, 85. Skinner, H. B., 86. Terry, T. P., 87.

New eclectic magazine. See McSherry, R. 48

New Mexico. See Cutts, J. M., 35. Rives, G. L., 6. U. S. State dept. Message of Pres. 37

New Mexico, Campaign in. Edwards, F. S., 43

New Mexico, Conquest of. See Conquest. See also Conquest of Santa Fé, 34.

New trails in Mexico. Lumholtz, K. S. 81

New York Herald. July 11, 1850. See Webster, D. 69

New York historical society. See McWhorter, G. C. 36

New York volunteers. See The high private 45

Nichols, Wm. A., Lieut., 1817-1869.

Page
Reilly, J. 49
Niox, G. L. Armée et marine. See Le Mexique 84
Nisbet, J. See Soulé, F. 7
Noll, A. H. From empire to republic 5
North American review. See Webster, D. 69
Northern Mexico, Sketches of campaign in. Giddings, L. 45
Northern Mexico, Sketches of the war in 52
North American states, History of. Bancroft, H. H. 3, 4
North Mexican states. Bancroft, H. H. 3, 4
Norton, F. H. Life and public services of W. S. Hancock 57
Notes written during the Mexican war on both lines of operation. (In German.) Zirckel, O. 33
Number, etc., of persons employed. U. S. Navy dept. 74

Oaxaca. See Blichfeldt, E. H. 77
O'Brien, John P. J. d. 1850. Life. Gen. Taylor and his staff 64
Occasional papers, U. S. Engineer School. No. 16. See Smith, Gust. W. 52
Occupation of Mexican territory. U. S. Pres. Message 24
"An officer of the U. S. A." See Life and public services of Gen. Z. Taylor 64-65
Officers killed, wounded, etc. U. S. War dept. Report 32
Officers, Military record of. See Rodenbough, T. F. 50
Officers serving in Mexican war. See Roster of officers.
Officers who marched with army under Scott. U. S. Adjt. Gen.'s office 53-54
Official reports. See Thorpe, T. B. Our army on the Rio Grande 53
Ohio, 5th Infantry. See note in Jamieson, M. 46
Ohio volunters, Co. C, 2d regiment. See Jamieson, M. 46
Ohio volunteers, 1st regiment of. See

Page
Giddings, L. 45
Okee-cho-bee. See Fry, J. R., 63. Life and public services of Gen. Taylor, 64-65. Life of Gen. Taylor, 65.
"The one-legged sergeant." See A sketch of the life and character of Gen. Taylor 66
"One who has seen the elephant." See Scribner, B. F. Camp life of a volunteer 51
"One who was thar." See Scribner, B. F.
Operations, Line of U. S. army (map) See Grant, U. S. Personal memoirs 56
Operations of Gen. Price at Santa Fé. See Hughes, J. T. 35-36
Orderly in Mexico, A general's 45
Orders issued by Gen. Scott and Commodore Conner. See Temple, W. G. 52
Oregon. See Rives, G. L. 6
The Oregon country (map). See Rives, G. L. 6
Organization of the army of the U. S., An account of. Robinson, F. 18
Organization of the Mexican army. See Martin, P. F. 81
Ortiz, R. See Alcaraz, R. 8
Oswald, L. Summerland sketches 85
Oswandel, J. J. Notes of Mexican war 48
The other side. Alcaraz, R. 8
Our army at Monterey. Thorpe, T. B. 53
Our army on the Rio Grande. Thorpe, T. B. 53
Our artillery in Mexican war. Van Deusen, G. W. 54
Our battles in Mexico. See Fry, J. R., Life 63
Our cavalry in Mexico. Lane, W. B. 47
Our late conquest 20
Our war chest. See Relic of our war 49
Ozaca. See Oswald, F. L. Summerland sketches 85

Pacific coast. See Revere, J. W. 36
Pacific states, History of. Bancroft, H. H. 2, 3
Padierna, Battalla de. Schulz, E. E. 51
Padierna, Battle of. See Contreras.

Page

Palmer, F. Central America 85

Palmetto regiment. See Moore, H. J. Scott's campaign in Mexico 61

Palo Alto, Battle of. See A brilliant national record, 62. Fry, J. R., Life of Gen. Taylor, 63. Howard, O. O., Gen. Taylor, 64. Kendall, G. W., 47. Life and public services of Gen. Z. Taylor, 64-65. The life of Gen. Taylor, the hero, 65. Ripley, R. S., v. 1, 17. Rives, G. L., 6. Thorpe, T. B. Our army on the Rio Grande, 53. U. S. War dept. Report, 32. Wilcox, C. M., 32.

Pan-American union. See also International bureau of American republics. Mexico 85

Paredes. Mariano Paredes y Arrillaga, pres. Mexico, 1790-1849. See Robinson, F. 70

Parker, W. H. Recollections 73

Patterson, Robt., Maj. Gen., 1792-1881. See Anderson, R., 40. Gen. Scott and his staff, 60. See also A general's orderly, 45. Tilden, B. P., jr., 87. Portrait, see Wilcox, C. M., 32.

Payno y Flores, Manuel, 1810-1894. See Alcaraz, R. 8

Les pays modernes. See Bigot, R. 77

Paz, E. La invación norte americana en 1846 16

Peace with Mexico. Gallatin, A. See also Rives, G. L. 6

Peculiar service in Mexico. See Farragut, L. Life 71

Pencillings of scenes upon Rio Grande. Allen, L. L. 40

Pennington, Alex. C. M., Brig.-Gen., 1838- See Reilly, J. 49

Pennsylvania cavalry. See Lott, W. C. 48

Pennsylvania. Co. E, 2d Penna. regiment. See Hartman, G. W. 45

Pennsylvania volunteers, 1st regiment. See Oswandel, J. J. Notes 48

The people's life of Gen. Z. Taylor. See The life of Gen. Taylor, the hero 65

Perigny, M. de. Les Etats-Unis du Mexique 5

Page

Perote Castle. See Reilly, J. 49

Perry, M. C. (By) Griffis, W. E. 72

Persecutions of Mexican citizens. See U. S. Congress 88

Personal memoirs. Grant, U. S. 56

Personal recollections. Morehead, C. S. See Hughes, H. T. 36

Peterson, C. J. Military heroes of the war 16

Phelps, W. D. Fore and aft 73

Philadelphia grays 49

Picard, A. See Le Mexique 84

Pictorial history of Mexico. Frost, J. 12

Pictorial life of Gen. Taylor 66
See also The life of Gen. Z. Taylor, the hero, 65.

Picturesque Mexico. Wright, Mrs. M. R. 89

Pierce, Franklin, 1804-1869. Life. See Gen. Scott and his staff, 60. McSherry, R. Mexican campaign sketch 48

Pike, Albert, 1809-1891. Buena Vista. (A poem.) See Rodenbough, T. F. 50

Pillow, Gideon Johnson, 1806-1878. Life. See Gen. Scott and his staff. 60. U. S. War dept. Letter, 27. Portrait, see Wilcox, C. M., 32.

Pillows and Quitman's attacks. See Kendall, G. W. 47

Pino Village, Wagon route to. See U. S. Engineer dept. 38

''Pioneer Corps.'' See Reilly, J. 49

Plan del Rio. See Wheeler, J. B. 32
Wilcox, C. M., 32.

Platt, D. Gen. G. H. Thomas, a critical biography 70

Point Isabel. See Reilly, J., 49. See also map, in Rives, G. L. 6

Ponce de León, G. El interinato presidencial de 1911 5

Pope, John, Top. Engineers, 1823-1892. See U. S. Pres. Message 23

Popocatepetl from Puebla. See Anderson, R. 40

Porter, C. T. Review of the Mexican war 17

Porter, David Dixon, 1813-1891. Soley,

Page
J. R. 74
Postal service, Mexico. See Lagrave, M., Postes et télégraphes. In Le Mexique, 84. Moore, H., Railway guide, 110. Mexican year book, 82.
Powell, C. F. Life of Maj. Gen. Taylor 66
Prescott, W. H. See Calderón de la Barca, F. E. I. 78
Price, Sterling, 1809-1867. Price's despatch, and sketch accompanying despatch. See U. S. Pres. Message, 23. Portrait, see Wilcox, C. M., 32
Price, Sterling. (His) operations at Santa Fé. See Hughes, J. T. 35-36
Prieto, Guillermo, 1813- See Alcaraz, R. 8
Prince, F. O. See Goodrich, F. E. 57
Prisoners, Mexican war. See Encarnación prisoners 44
A private's own journal. Hartman, G. W. 45
Progreso. See Kendall, J. S. Seven Mexican cities 81
Public works, Mexico. See Krantz, C. Chemins de fer et travaux publics. In Le Mexique, 84. Mexico. Ministerio de comunicaciones y obras publicas. Anales de la Secretaria . . . and Memoria, 91. See also Martin, P. F., 81.
Puebla. See Hillard, G. St., 59. Rives, L., 6.
Puebla, March to Mexico from. See U. S. Adj. Gen.'s office. Lists 53-54
Puebla, Panorama of. See Anderson, R. 40
Puebla, Siege of. See Moore, H. J. Scott's campaign in Mexico 61
Puebla de Los Angeles. See Anderson, R. 40
Puebla de Taos, Battle of. See U. S. Pres. Message 23
Puebla, March to Mexico from. See Lane, W. B., 47. U. S. Adj.-Gen.'s office. Lists, 53-54
Pyramid of Cholula. See Anderson, R. 40
El puchero. McSherry, R. 48

Page
Queretaro. See Kendall, J. S. 81
Queretaro, Treaty at. See U. S. State dept. 26
Quintas y Arroya, General Juan. See Martin, P. F. 82
Quisenberry, A. C. History by illustration 66
Quitman, John Anthony, 1799-1858. Life. Claiborne, J. F. H., 60. See also Gen. Scott and his staff, 60. Portrait, see Wilcox, C. M., 32.
Quitman. See also Pillow's and Quitman's attacks.
Quitman's report. See U. S. Pres. Message 23

Railroads, Mexico. Anderson, A. D. Tehuantepec inter-ocean railroad, 90. Baz, G. History of the Mexican railway, 90. Krantz, C. Chemins de fer . . . See Le Mexique, 84. Mexico. Ministerio de comunicaciones y obras publicas. Album, 91. Reglament, 92. Reseña historica, 92. Moore, H. Railway guide, 92. Martin, P. F., 81. Moses, B. The railway revolution in Mexico, 92. The railroads of Mexico, 92. Reavis, L. U. An international railway to the city of Mexico, 92. Romero, M. The Tehuantepec Isthmus railway, 93. Romero, M. Geog. and statistical notes, 86. Romero, M. Mexico and the U. S., 86. Torre, J. de la. Historia, 93. See also Campbell, R., 78. Garay, J. de. An account, 108. Mexican year book, 82. Pan-American union, Mexico, 85. U. S. Bureau of statistics, 93.—Public works, Mexico.
Railway guide. Moore, H. 92
Rambles in backwoods of Mexico. Oswald, F. L. 85
Ramirez, Ignacia, 1818-1879. See Alcaraz, R. 8
Ramirez, J. F. Mexico durante du guerra 6
Ramsey, A. C., Col. 11th Inantry. d.

Page

1869. See Alcaraz, R. The other side ---------- 8
Ramsey, George D., 1800-1882. Life. See Gen. Taylor and his staff ----- 64
Randolph, S. N. Life of Gen. Thom. J. Jackson ---------- 58
The Ranger's song. (Poem) by James T. Lytle. See Reid, S. C. ---------- 49
Read, B. M. Guerra Mexico-Americana ---------- 17
Reavis, L. U. An international railway to the city of Mexico ---------- 92
Reclus, E. See Le Mexique ---------- 84
Recollections of a naval officer. Parker, W. H. ---------- 73
Recollections of Mexico. Benham, H. E., 41. Thompson, W., 87.
Recollections of the Mexican war. Rowan, St. C. ---------- 73
Reconnaissance, Military. See U. S. Engineer dept. ---------- 38
Recuerdos de la invación. Roa Bárcena, J. M. ---------- 17
The regiment of mounted riflemen. Lane, W. B. ---------- 47
Regulars and volunteers engaged in in Mexican war. U. S. Adjt. Gen.'s office ---------- 20
Reid, S. C. Scouting expeditions ---------- 49
Reilly, J. An artilleryman's story ---------- 49
Reinosa. See Reilly, J. ---------- 49
Relic of our war with Mexico ---------- 49
Reminiscences of a campaign in Mexico. Robertson, J. B., 50. Smith, I. ---------- 52
Reminiscences of campaign on Rio Grande. Deas, G. ---------- 43
Reports, Military, from commanders of U. S. army. U. S. War dept. ---------- 30
Reprimand of Sec'y Marcy. See Taylor, Z. Gen. Taylor's letters ---------- 67
Resaca de la Palma, Battle of. See Thorpe, T. B. Our army on the Rio Grande, 53. U. S. War dept. Report, 32. See also A brilliant national record, 62. Fry, J. R., 63. Howard, O. O., Gen. Taylor, 64. Life and public services of Gen. Z. Taylor, 64-65. The life of Gen. Taylor, the hero, 65. Ripley, R. S., v. 1, 17. Rives, G. L., 6. Wilcox, C. M., 32.
Revere, J. W. A tour of duty in California ---------- 36
Revere, J. W. Keel and saddle ---------- 73
Review of reviews. See Brady, A. C. 77
Richardson, W. H. Journal ---------- 50
Ridgeley, Randolph, 1814-1846. Life. See Gen. Taylor and his staff ---------- 64
Riley, Bennet, 1786-1852. Commending Tower. See U. S. Pres. Message, 22. See Gen. Scott and his staff, 60. Wilcox, C. M., 32.
Ringgold, Sam., 1800-1846. See Fry, J. R., Life of Gen. Taylor, 63. Gen. Taylor and his staff, 64. Powell, C. F. Life of Taylor, 66.
Rio del Norte, Troops on. See U. S. Pres. Message ---------- 21
Rio Grande. Allen, L. L., Pencillings. 40. Stratemeyer, E. With Taylor on the Rio Grande, 67. Tilden, B. P., jr. Notes on the Upper Rio Grande, 87. See also Smith, I., 52.
Rio Grande, Army on. U. S. War dept. ---------- 27
Rio Grande, Campaign on. Deas, G. ---------- 43
Stevens, I. I. ---------- 19
Rio Grande, Map of operations on. See U. S. Engineer dept. Report ---------- 54
Rio Grande, March of Kentucky cavalry from Louisville to. See Encarnación prisoners ---------- 44
Rio Grande, Our army on the. Thorpe, T. B. ---------- 53
Rio Grande, Passage of. See Relic of our war ---------- 49
Rio Puerco, Survey of. See U. S. Engineer dept. ---------- 38
Rio San Gabriel, Passage of. See U. S. Engineer dept., 38. U. S. Pres. Message, 23.
Ripley, R. S. The war with Mexico ---------- 17
Rivers, Mexico. See Campbell, R., 78. Martin, P. F., 81. Skinner, H. B., 86. Terry, T. P., 87.
Rives, G. L. The U. S. and Mexico ---------- 6

Page

Roa Bárcena, J. M. Recuerdos de la invación 17
Roads. See Jamieson, M. Journal notes, 46. See also Mexico, Guides.
Robarts, W. H. Mexican war veterans 17
Roberts, B. K., Brig. Gen. See U. S. Adjt. Gen.'s office. Official 53-54
Robertson, J. B. Reminiscences 50
Robinson, F. An account of organization of the army of U. S., 18. Mexico, and her chieftains, 70.
Rodenbough, T. F. From everglade to cañon 50
Roland, John Fred., Major, 1818-1852. See Reilly, J. 49
Roman, A. Military operations of Gen. Beauregard 55
Romance of military life. See Cooke, P. St. G. Scenes 79
Romero, M. Geographical and statistical notes on Mexico, 86. Mexico and the U. S., 86. The Tehuantepec Isthmus railway, 93.
Romula de la Vega, General. See Robinson, F. Mexico 70
Roosevelt, Theodore, pres. U. S., 1858- See Fornaro, C. de Diaz, czar of Mexico 55
Ross, G. M. von. See Wislizenus, A. 37
Root, Elihu, 1845. Morales, V., El Señor Root en Mexico 84
Roster of Kentucky troops and officers.. See Quisenberry, A. C. 66
Roster of navy officers, Mexican war. See Wilcox, C. M. 32
Roster of officers. See Kenly, J. R. 47. U. S. Adjt. Gen.'s office. Lists, 53-54.
Roster of officers and troops. See McSherry E., El puchero, 48. Reid, S. C., 49.
Roster of troops. See Hartman, G. W. 45
Roster of volunteer officers, Mexican war. See Wilcox, C. M. 32
Roster of volunteers. See McSherry, R. El puchero 48
Rough and ready almanac. See Gen. Taylor's 64

Page

Rough and ready reckoner. See also The Taylor text-book 69
Rowan, St. C. Recollections of the Mexican war 73
Royce, J. California 37
Rurales, Mexico. See Martin, P. F. 81
The Sabine River (map). See Rives, G. L. 6

Saborio N. See Alcaraz, R. 8
Sacramento River, Battle of. See U. S. Pres. Message, 23. Map of battleground. See Rives, G. L., 6.
St. Patrick company. See Hopkins, G. T. 46
Saltillo, March from San Antonio to. See Baylies, F., 41. U. S. Engineer dept., 54.
Samson, W. H. See Taylor, Z. Letters of Z. Taylor 67
San Antonio, March from Saltillo to. See Baylies, F., 41. Reilly, J., 49. U. S. Engineer dept. Report, 54.
San Cosme Gate (Garita). See Hillard, G. St., 59. Reilly, J., 49. Rives, G. L., 6. U. S. Pres. Message, 22.
San Diego, March from Santa Fé to. Cooke, P. St. G., 35. U. S. Engineer dept., 38.
San Francisco, Annals of. Soulé, F. 7
San Francisco, History of. Hittell, J. S. 4
San Jacinto. See Rives, G. L. 6
The San Jacinto campaign (map). See Rives, G. L. 6
San Jacinto veterans. See Lane, W. P. 47
San Juan d'Ulloa. See A brilliant national record, 62. Conner, P. S. P., 71.
San Juan Teotihuacan. See Maxson, H. R. 82
Pan Patricio battalion. See Hopkins, G. T., 46. Ripley, R. S., v. 2, p. 258, 261, 355. 17. Wilcox, C. M. (p. 225, 382, 392-395.) 32. See also Deserters.
San Pasqual, Actions at. See U. S.

Page

Engineer dept., 38. U. S. Pres. Message, 23.

Santa Anna, A. L. de, Detall de las operaciones, 51. Las guerras, 18. See also Anderson, R., 40. Mansfield, E. D., 15. Rives, G. L., 6. Robinson, F., 70. Portrait, see Wilcox, C. M., 32.

Santa Anna's letter and note,see U. S. Pres. Message 21

Santa Anna's plan. See U. S. Pres. Message 21

Santa Fé, Conquest of. See Conquest 34

Santa Fé, Operations at. Hughes, J. T. 35, 36

Santa Fé, Report of march from. Cooke, P. St. G. 35

Santillán, R. See Aguilar y Santillán, R. 76

Sappers and Miners C°. See Hillard, G. St Life of McClellan, 59. Reilly, J., 49. U. S. Pres. Message, 22. Wilcox, C. M., 32.

Satterlee, Rich. S., Surgeon, d. 1880. See Reilly, J., 49

Saylor, Sergt., O., Co. H, 2d Artillery: Planted colors of regt. on fortications of enemy near bridge at Chapultepec. See Reilly, J. 49

Scenes and adventures in the army. Cooke, P. St. G. 79

Scenes de la vie militaire au Mexique. Bellemare, L. 77

Schiafino, F. See Alcaraz, R. 8

Schulz, E. E. Batalla de Padierna 51

Scott at Puebla. See Rives, G. L. 6

Scott's battles in Mexico. Bonner, J. 42

Scott's campaign. See Ballentine, G. 41. Hartman, G. W., 45. McSherry, R. El puchero, 48. Moore, H. J., 61. Rodenbough, T. F., 50. Semmes, R., 74.

Scott's correspondence. See U. S. State dept. Correspondence, 24. U. S. War dept., 24, 26.

Scott's entrance into the city of Mexico. See Kendall, G. W., 47. Wilcox, C. M., 32.

Scott, W. General order no. 111. See

Page

Wheeler, J. B., 32. General order no. 376. See U. S. War dept., 29. See also Temple, W. G., 52.

Scott, General, and his staff 60

Scott. Illustrated life of Gen. W. 61

Scott, W. Letters of, and of Sec'y Marcy 61

Scott. Life of Gen. W. Scott 61

Scott, W. Line of operations of his army. See U. S. Pres. Message 23

Scott. Mansfield, E. D. Life of Gen. W. Scott 61

Scott. Moore, H. J. Scott's campaign in Mexico 61

Scott, W. Memoirs by himself 61

Scott, W. Orders by him. See Temple, W. G., 52. See also Scott, W. General orders.

Scott, W., Report to, by Gen. Pillow See U. S. War dept. Letter 27

Scott. Sumpter, A. The lives of Gen. Z. Taylor and ... 67

Scott. Wright, M. J. Gen. Scott 62

Scott, W. See also Anderson, R. 40. Complete history of late Mexican war, 11. Taylor and his generals, 68. U. S. Pres. Message, 22.

Scouting expeditions. Reid, S. C. 49

Scribner, B. F. Camp life 51

Scribner B. F. A campaign in Mexico 51

Seaports, Mexico. See Campbell, R., 78. Martin, P. F., 81. The Mexican year book, 82. Skinner, H. B., 86.

Sedgwick, John, Lieut., 1813-1864. See Reilly, J. 49

S gura, F. See Alcaraz, R. 8

Selous, H. C. Burford, R.

Semmes, R. Service afloat 74

''Senex.'' See McPherson, J. D. 15

A series of intercepted Mexican letters. Smith, Robt. H. 52

Service afloat and ashore. Semmes, R. 74

Seven Mexican cities. Kendall, J. S. 81

Sevier, A. H. War with Mexico, 19. See also Correspondence.

Shackford, C. C. A citizen's appeal 19

Page

Shackleford, Muscoe L., Lieut., 1813-1847. See Reilly, J. ____________ 49

Sheppard, Morris, 1875- See Conditions in Republic of Mexico _____ 78

Sherman, Thomas West, 1813-1879. Life. See Gen. Taylor and his staff 64

Sherman, Wm. Tecumseh, 1820-1891. See Hudnut, J. M. Commanders_ 70

Shields, James, 1810-1879. Life. See Gen. Scott and his staff, 60. See also Bishop, W. W., 42. Reilly, J., 49. Portrait, see Wilcox, C. M., 32.

A short statement of the causes ____ 19

Sierra Caliente. See Lumholtz, K. S. Unknown Mexico _______________ 81

Sierra de Jumanes, Survey of. See U. S. Engineer dept. ___________ 38

Sierra Grande, Survey of. See U. S. Engineer dept. __________________ 38

Sierra Madre. See Lumholtz, K. S. Unknown Mexico, 81. Smith, Isaac, 52.

A sketch of the life and character of Gen. Taylor ____________________ 66

A sketch of the life and public services of Gen. Z. Taylor ___________ 67

Sketches of the Mexican war______ 51

Sketches of the war in northern Mexico ____________________________ 52

Skinner, H. B. Mexico in miniature_ 86

Slidell, John, 1793-1871. Instructions to, 24. See also Correspondence.

Slidell's mission. See Rives, G. L.__ 6

Sloat, John Drake, 1780-1867. Letters, etc. See U. S. War dept. Messages of Pres.__________________ 29

Smith, F. H. A white umbrella in Mexico _________________________ 86

Smith, G. W. Company A, Corps of Engineers ______________________ 52

Smith, G. W. Report. See U. S. Pres. Message, 22. Wilcox, C. M., 32.

Smith, Isaac. Reminiscences of a campaign in Mexico _____________ 52

Smith, Joseph, Martyrdom of. See Tyler, D. ______________________ 53

Smith, Martin Luther, 1819-1866. See U. S. War dept. Report of Sec'y of war ___________________________ 31

Smith, Persifor Frazier, 1798-1858. Life. See Gen. Scott and his staff, 60. Frontier service, 44. Portrait, see Wilcox, C. M., 32.

Smith, R. C. See Maclay, E. St.__ 72

Smith, Robt. H. Series of intercepted Mexican letters ________________ 52

Snow, Miss E. R. The Mormon battalion, and first wagon road over the great American desert. See Tyler, D. _____________________________ 53

"A soldier of the old guard." See Ethics in action ________________ 55

Sonora. See Lumholtz, K. S. New trails in Mexico ________________ 81

Soulé, F. Annales _________________ 7

The South American series ,ed. by M. Hume. See Enock, C. R.__________ 79

Southern magazine. See Frontier service _____________________________ 44

Spain, Kingdom of (Map). See Rives, G. L. ___________________________ 6

Stanley, Sam., Private, 2d Artillery. See Reilly, J. __________________ 49

Steamship lines, Mexico. See Campbell, R. ________________________ 78 Martin, P. F., 81. Mexican year book, 82. Moore, H., 92. Romero, M., 86.

Stearns, C. Facts in the life of Gen. Taylor _________________________ 67

Steele, J. W. To Mexico by palace car 86

Steele, Matthew Forney, 1861- See U. S. General staff. . . . American campaigns ______________________ 20

Sterling, M., Capt. See Tilden, B. P. jr. _______________________________ 87

Stevens, George, Lieut., 1823-1846. See Relic of our war _____________ 49

Stevens, I. I. Campaigns of the Rio Grande ____________________________ 19

Stevens, Isaac Ingalls, 1818-62. (Engineers.) Wounded. See Wilcox, C. M. ____________________________ 32

Stockton, Robt. Field, 1796-1866. Stockton's campaign. See Rivere, J. W. Keel and saddle, 73. Let-

Page

ters, etc. See U. S. War dept. Messages of Pres., 29. Operations. See Revere, J. W., 36. Portrait, See Wilcox, C. M., 32.

Stonewall Jackson. See Jackson, Thomas J.

Stratemeyer, E. With Taylor on the Rio Grande 67

Strother, D. H. See Illustrated life of Gen. Scott 61

Summerland sketches. Oswald, F. L. 85

Sumpter, A. The lives of Gen. Z. Taylor and Gen. W. Scott 77

Tabasco, Expedition to. See Maclay, E. St., 72. Second attack. See Maclay, E. St., 72.

Table-lands, Mexico. See Campbell, R. 78

Tacabuya. See Reilly, J. 49

Tacabuya. American guard at. See Smith, R. H. 52

Tactics of Mexican war. See Hillard, G. St. 59

Tampico. See Hillard, G. St., 59. Kendall, J. S. 81

Tampico, View of. See Anderson, R. 40

Tampico, Wharf at. See Martin, P. F. 81

Tarascos of Michoacan. See Lumhotz, K. S. Unknown Mexico 81

Tattnall, J., jr., 1796-1871. Jones, C. C. Life and services of 72

Tattnall's attack. See Maclay, E. St. 72

Taylor, F. W. The broad pennant 74

Taylor, J. Martyrdom of Jos. Smith, See Tyler, D. 53

Taylor, Zachary, 1784-1850.

- Taylor and Fillmore. Life of Maj. Gen. Taylor 68
- Taylor and his campaigns 68
- Biographical notes. See Taylor, Z. Letters of 67
- A brilliant national record 62
- Taylor's campaign. See A brilliant national record 62
- Conrad, R. T. A sketch of the life of. See Fry, J. R. 62-63

Page

- Davis, J. Speech of Hon. J. Davis 62
- Despatches. See A brilliant national record, 62. Thorpe, T. B. Our army on the Rio Grande, 53. U. S. War dept., 27, 30.
- Frost, J. Life of Maj. Gen. Z. Taylor 63
- Fry, J. R. Life of Gen. Taylor 63
- Gen. Taylor and his staff 64
- Howard, O. O., Gen. Z. Taylor 64
- Letters. See Taylor, Z. Letters, 67. Thorpe, T. B. The Taylor anecdote book, 69.
- Life and public services of Gen. Z. Taylor 64-65
- The life of Gen. Taylor, the hero 65
- Montgomery, H. The life of Maj. Gen. Z. Taylor 66
- Operations in Mexico, Map of. See Fry, J. R. Life 63
- Pictorial life of Gen. Taylor 66
- Quisenberry, A. C. History by illustration 66
- Reply to Gaines' letter. See U. S. War dept. 30
- Reports. See U. S. Pres. Message 21-22
- A sketch of the life and character 66
- A sketch of the life and public services of Gen. Z. Taylor 67
- Stratemeyer, E. With Taylor on the Rio Grande 67
- Sumpter, A. The lives of Gen. Z. Taylor and . . . 67
- Taylor and Fillmore. Life of Maj. Gen. Z. Taylor 68
- Taylor and his campaigns 68
- Taylor and his generals 68
- Taylor's letters. See Taylor, Z. 67
- Taylor's text-book, . . . 69
- Thorpe, T. B. The Taylor anecdote 69
- Webster, D. Remarks of 69
- Wright, H. C. Dick Crowningshield 69
- See also Anderson, R., 40. Complete history of the late war, 11. Scott, W. Memoirs, 61. Thorpe, T. B. Our army at Monterey, 53.

Taylor, Z. Correspondence. U. S. State dept. Correspondence, 24. U. S. War dept., 26-27. (Complete

Page

compilation) U. S. War dept. Messages of the Pres., 29.
Tehuantepec, Account of the Isthmus of. Garay, J. de 90
Tehuantepec inter-ocean railroad. Anderson, A. D. 90
Tehuantepec interoceanic route. Corthell, E. L. 93
The Tehuantepec Isthmus railway. Romero, M. 93
Tehuantepec route. See The Mexican year book 82
Telegraph service, Mexico. See Lagrave, M. Postes et telegraphes, in Le Mexique, 84. Moore, H. Railway guide, 92. U. S. Bureau of statistics, 93
Temple, Wm. Grenville, 1824-1894. Memoir of landing of U. S. troops, 52. (In Connor, P. S. P. The Home Squadron, 71.)
Tennessee cavalry. See Furber, G. C. 44
Tennessee, Commanders of the Army of. Hudnut, J. M. 70
Tepic. See Lumholtz. K. S. Unknown Mexico 81
Terry, T. P. Terry's Mexico; handbook for travellers 87
Texas. See Rives, G. L. 6
Texas, History of. Bancroft, H. H., 2. History of, by ''A traveller,'' 13. See also Bancroft, H. H. History of Pacific Sattes, v. 11, 2-3.
Texas, Map of operations in. See U. S. Engineer dept. Report 54
Texas Mounted Riflemen, 1st. See Lane, W. P. 47
Texas ranger, The. See Reid, S. C., 49. Sketches of Mexican war, 51.
Thirty years' view. Benton, T. H. 10
Thomas, George Henry, 1816-1870. Coppée, H. Gen. Thomas, 69. Johnson, R. W. Memoir of Maj. Gen. G. H. Thomas, 69. Platt, D. Gen. G. H. Thomas, 70. Van Horne, T. B. The life of Maj. Gen. Thomas, 70.
Thompson, W. Recollections of Mexico 87

Page

Thornton Seth B., d. 1847. Life. See Gen. Scott and his staff, 60. See also Reilly, J., 49.
Thorpe, T. B. Our army at Monterey. 53. Our army on the Rio Grande, 53. The Taylor anecdote book, 69.
Three years in California. Colton, W. 34
Through Modern Mexico. Gadow, H. F. 80
Tilden, B. P. jr. Notes on upper Rio Grande 87
To-day in the land of to-morrow. Moses, J. T. 85
Toluca. See Maxson, H. R., Practical guide 82
To Mexico by palace car. Steele, J. W. 86
''Tom Owen, the bee-hunter,'' See Thorpe, T. B.
Topographical Engineers, Roster. See Wilcox, C. M. 32
Torre, J. de la. Historia y descrición del ferrocarril Central mexicano 93
Torrescano, P. M. See Alcaraz, R. 8
Tortillas. See Anderson, R. 40
Totten, Joseph Gilbert, 1788-1863. Report. See Hillard, G. St., 59. U. S. Pres. Message. 21-22. Wilcox, C. M., 32.
Tour of duty in California. Revere, J. W. 36
Tower, Zealous Bates, Engineers.1819-1900. Tower commended by Col. Riley. See U. S. Pres. Message, 22. Wilcox, C. M., 32.
Townsend, Edward Davis, 2d Artillery, 1817- See Reilly, J. 49
Transportation, Mexico. See also Railroads,Mexico—Steamship lines. See Mexican year book, 1908-1913, 82. Martin, P. F., 81. Moore, H. Railway guide, 92. U. S. Bureau of statistics, 93.
'A Traveller.'' See History of Texas 13
Travels and adventures in Mexico. Carpenter, W. W. 43
Treaty between U. S. and Mexico. See

Page

Kenly, J. R., 47. U. S. State dept., 25-26. U. S. War dept. Message from the Pres., 27.

Treaty of Guadalupe Hidalgo. See Rives, G. L. ________ 6

Treaty ratified. See Rives, G. L.____ 6

Trist, Nicholas P., 1798-1875. See also Correspondence.

U. S. State dept. Correspondence__ 24

Turnbull, Wm., Top. Engineers, 1800-1874. See U. S. Pres. Message____ 23

Turner, J. K. Barbarous Mexico___ 87

Tuspan, Fall of. See Maclay, E. St. 72

Tuttle, I. F. Our late conquest____ 20

Tweedie, E. B. H. The maker of modern Mexico ________ 56

Twelve months' campaign. See Bishop, W. W. ________ 42

Twelve months volunteer. Furber, G. C., 44. See also Jamieson, M. ____ 46

Twiggs, David Emanuel, 1790-1862. Life. See Gen. Scott and his staff, 60. Report of. See Hillard, G. St., 59. Portrait, see Wilcox, C. M., 32.

Twiggs, Levi, 1793-1847. Life. See Gen. Taylor and his staff, 64. See also Gen. Taylor and his generals, 68.

Twitchell, R. E. History of the military occupation ________ 37

Two wars. French, S. G. ________ 12

Tyler, D. Concise history of Mormon battalion ________ 53

Tyler, R. E. Mexico, past, present, future ________ 87

United service. See Conner, P. S. P. 71

United service magazine. Lane, W. B. 47

United service review. See Grindall, J. J. ________ 45

U. S. Adjt. Gen.'s office. Lists of officers, 53. Official. List, 54. Military forces, 20. Regulars and volunteers, 20.

U. S. Bureau of statistics . . . Commercial Mexico________ 93

U. S. Congress. Committee on foreign affairs. War with Mexico ________ 20

U. S. Congress. House. Committee on rules. Hearings ________ 88

U. S. Engineer dept. Notes of military reconnaissance, 38. Report, 54.

U. S. General staff. American campaigns ________ 20

U. S. Navy dept. Annual report, 1847. 74

U. S. Naval institution. Proceedings. See Dupont, S. F. ________ 71

U. S. Pres. Message ________21-23

U. S. Pres. Occupation of Mexican territory ________ 24

U. S. Pres. Refusal to furnish instructions to Slidell ________ 24

U S. State dept. Correspondence.__ 24

U. S. State dept. New Mexico and Cal. Message ________ 37

U. S. War dept. Claims growing out of insurrection in Mexico ________ 88

United States consulate in California. Kelsey, R. W. ________ 4, 5

"Universal." See Romero, M.____ 93

Unknown Mexico. Lumholtz, K. S._ 81

Upper California (map). See Rives, G. L. ________ 6

Urquidi, F. See Alcaraz, R. ________ 8

Vagabond life in Mexico. Bellemare, L. ________ 77

The Valley of Mexico. See Campbell, R., 78. Hillard, G. St., 59. U. S. Engineer dept. Notes, 38. U. S. War dept. Report, 31.

The Valley of Mexico (map). See Rives, G. L., 6. Grant, U. S. Personal memoirs, 56. U. S. Pres. sage, 23. U. S. War dept. Report of Sec'y of War, 31. Ripley, R. S. v. 2, 17. Wilcox, C. M., 32.

Van Deusen, George W., 1859- Our artillery in the Mexican war______ 54

Van Horne, T. B. The ife of Maj. Gen. G. H. Thomas ________ 70

Vega, De la. See Romula de la Vega.

Velasco, E. See Mexico. Ministerio de Comunicaciones y obras publicas. Reseña, 92.

Vera Cruz. See Blichfeldt, E. H., 77. Conner, P. S. P., 71. Farragut, L.,

Page

Life, 71. Hillard, G. St., 59. Hitchcock, E. A., Fifty years, 58. Kendall, J. S., 47. McSherry, R. Mexican campaign sketch, 48. Parker, W. H., Recollections, 73. Rives, G. L., 6.
Vera Cruz, Bombardment. See Kendall, G. W., 47. Maclay, E. St., 72.
Vera Cruz, Capture of. See Capture. 43
Vera Cruz, Landing at. See U. S. Pres. Message, 22. Lott, W. C., 48. Ripley, R. S., 17. Temple, W. G., 52. Wilcox, C. M., 32.
Vera Cruz, Siege of. See Anderson, R., 40. McSherry, R. El puchero, 48. Ripley, R. S., v. 2, 17. Wilcox, C. M., 32.
Vera Cruz, to city of Mexico (map). See Rives, G. L., 6. Distances. See Hartman, G. W., 45. Ripley, R. S., v. 2, 17. Wilcox, C. M., 32.
Vergara, Camp. See McSherry, R. 48
Vera Paz. See Owsald, F. L. Summerland sketches 85
Victories, Late, in Mexico 48
Vindication of volunteers. See Smith, R. H., 52
Vinton, John Rogers, ca. 1795, d. 1847. Life. See Gen. Scott and his staff 60
Virginia association of Mexicans. See Grindall, J. J. 45
Viva Mexico! Flandreau, C. M. 79
Volunteers, Vindication of. See Smith, Robt. H. 52

Wagon road over . . . desert. See Tyler, D. 53
Wagon route from Rio Grande to Pino Village. See U. S. Engineer dept. 38
Walker, F. A. Gen. Hancock 57
Walker, Sam. Hamilton, 1815-1847. Life. See Gen. Taylor and his staff, 64. See also Reilly, J., 45.
Walker, Wm. H. T., Mej. Gen., 1817-1864. Life. See Reid, S. C. Scouting expeditions 49
The War and its warriors 32

Page

War, Elements of art and science of. Wheeler, J. B. 32
War in the Mexican Gulf. See Maclay, E. St. 72
Washington volunteers. See Kenly, J. R. 47
Watson, Wm. H., d. 1846. Life. See Gen. Taylor and his staff 64
"Webfoot." See Phelps, W. D.
Webster, Daniel. [The life of Taylor.] Remarks 69
Wharves. See Tampico, Wharf at.
Wheeler, J. B. Courses of instruction in elements of art and science of war 32
A white umbrella in Mexico. Smith, F. H. 86
Whiting, Levi, d. 1852. Life. See Gen. Taylor and his staff 64
Wilcox, C. M. History of the Mexican war, 32. See also Hamilton, J., 13. Lane, W., 15.
Willard, E. H. Last leaves 33
The Wilmot proviso. See Rives, G. L. 6
Wilson, Henry Lane, 1857- Record of. See Mexico (City) Committee 84
Wilson, Wm. Bauchop, 1862- See U. S. Congress 88
Winfield, the lawyer's son. See Denison, C. W. Hancock 57
Winter, N. O. Mexico and her people of to-day 88
Winton, G. B. Mexico to-day 89
Wislizenus, A. Memoir of a tour 37
With Taylor on the Rio Grande. Stratemeyer, E. 67
Wood, Wm. Maxwell, 1809-1880. Services of. See McWhorter, G. C. 36
Wool, John Ellis, 1784-1869. Wool's campaign in Mexico. Baylies, 41. See also Baylies, F., 9. Buloup, J. W., 42. Gen. Taylor and his staff, 64. Taylor and his generals, 68. Portrait, see Wilcox, C. M., 32.
Wool's Correspondence. See U. S. War dept. 28
Wool's March . . . See U. S. Engineer dept. Report 54

Page

Wool's Report. See U. S. Pres. Message 21
The world to-day series. See Goodrich, J. K. 80
Worth, Wm. Jenkins, 1794-1849. See Anderson, R., 40. Gen. Taylor and his staff, 64. Semmes, R., 74. Taylor and his generals, 68. Portrait, see Wilcox, C. M., 32.
Worth's operations. See U. S. Pres. message 22, 23
Wounded, . . . See also Killed, . . . See Gen. Taylor and the Mexican war, 64. Reid, S. C., 49.
Wright, H. C. Dick Crowningshield 69
Wright, Marcus Joseph, 1831- Gen. Scott 62
Wright, Marcus Joseph, 1831- joint author. See Long, A. L. Memoirs of R. E. Lee 59
Wright, Mrs. M. R. Mexico, a history, 7. Picturesque Mexico, 89.

Yánes, Francisco J. See International bureau of American republics, 80. Pan-American union, 85.
Yell, Archibald, 1797-1847. Life. See Gen. Taylor and his staff 64
Yochimilco. See Maxson, H. R. 82
Young, P. History of Mexico 7
Yucatan. See Arnold, C. The American Egypt, 76. See also Blichfeldt, E. H., 77. Oswald, F. L. Summerland sketches, 85.

Zayas, E. R. de. Les Etats-Unis Mexicains 89
Zirckel, O. Tagebuch 33

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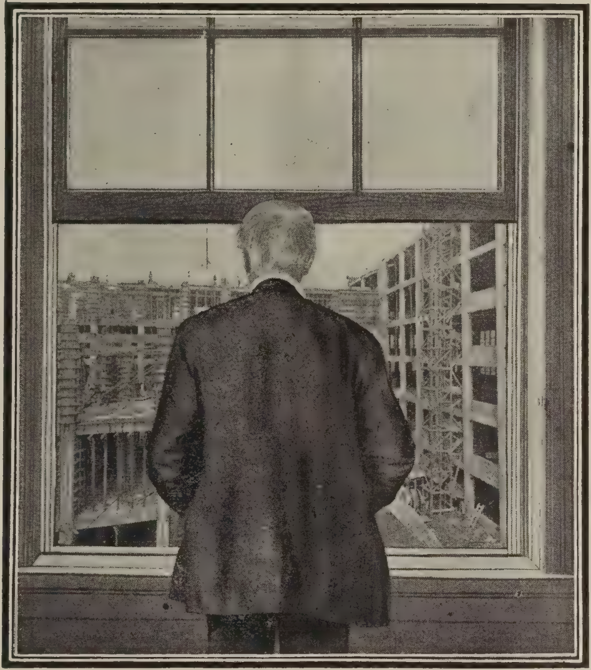

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Alphabetical List of Advertisers

	Page
Ambursen Company	xxvi
American Hoist and Derrick Co.	xxix
Bayonne Casting Co.	xlv
Bausch & Lomb Optical Co.	xx
Berger, C. L., & Sons	xxi
Bowers Southern Dredging Co.	xliv
Brandis Sons Co.	xxiii
Bristol Co.	xxiv
Buff & Buff Mfg. Co.	xxii
Broderick & Bascom Rope Co.	xxxiv
Channon, H., Co.	xxxvi
Clyde Iron Works	xxxviii
Contractors' Plant Mfg. Co.	xlii
Deming Co., The	xxxiii
Diamond Expansion Bolt Co.	xxiv
Edison Storage Battery Co.	ii-iii
Engineering Record	xviii
Ellicott Machine Corporation	xlvii
Fibre Conduit Co.	xxxvii
General Electric Co.	xl
Goldschmidt Thermit Co.	xlvi
Great Lakes Dredge and Dock Co.	xlviii
Gurley, W. & L. E.	xix
Icy-Hot Bottle Co.	xviii
Insley Mfg. Co.	xxxii
Ingersoll Rand Co.	xli
Jones and Laughlin Steel Co.	xxxv
Keuffel & Esser	xxii
Kroeschell Bros. Ice Machine Co.	xliii
Lackawanna Steel Co.	xxxi
Leschen, A. & Sons Rope Co.	xxxiv
Lidgerwood Mfg. Co.	xxxix
Lufkin Rule Co.	xviii
Ludlow Valve Mfg. Co.	xxx
Maryland Dredging & Contr. Co.	xliii
Mietz, August	xxiv
Morris Machine Works	xxxvi
National Lead Co.	xxx
Norfolk Creosoting Co.	xlii
Rodgers Sand Co.	xxv
Roebling's, John A., Sons Co.	xxxiv
Ross, P. Sanford, Inc.	xliv
Sauerman Bros.	xxvii
Scherzer Rolling Lift Bridge Co.	xxviii
Strauss Bascule Bridge Co.	xxvii
Warren-Knight Co.	xxii

Classified Directory of Advertisers

Air Compressors—
Lidgerwood Manufacturing Co.
Mietz, August.

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Ingersoll-Rand Co.

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Sauerman Bros.

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Ludlow Valve Mfg. Co.

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- Bowers Southern Dredging Co.
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- Mietz, August.

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- American Hoist and Derrick Co.
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- Ambursen Hydraulic Construction Co.

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- Keuffel & Esser.
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- Northwestern Expanded Metal Co.

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- Engineering Record.

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- Bayonne Casting Co.

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AERIAL NAVIGATION.

The military value of aerial navigation. (14), Sept. 17, 1914.

BREAKWATERS.

Effect of storms on breakwaters. (15), June 13, 1914.—Wave damage to the harbor beach breakwater, Lake Huron. (12), July 22, 1914. D.—Work on the east breakwater. (41), Aug. 12, 1914.

BULKHEADS.

Dock walls, gangway and gangway bridge, Barge Canal terminals, Troy, N. Y. (12),

July 22, 1914. D.—Bronx terminal, N. Y. City. J. B. Marsh. (15), June 27, 1914. D. I.—The Savannah River levee, Augusta, Ga. N. Wingfield. (14), Aug. 6, 1914. D. I.

CABLEWAYS.

Concreting the Arrowrock Dam. C. H. Paul. (15), Aug. 8, 1914. I.—Moving a steam shovel by two cableways. (15), Aug. 8, 1914.

CAISSONS.

Bridge foundations and the use of pneumatic caissons for constructing bridge foundations in Canada. (12), Sept. 23, 1914. D.—Gun platform foundations. (15), June 13, 1914. D.

CANALS.

Cape Cod canal. (15), June 6, 1914. I.—Concrete lining, Franklin Canal, Rio Grande project. L. M. Lawson. (14), Sept. 10, 1914. D. I.—The official opening of the Cape Cod canal. (14), Aug. 6, 1914. I; (27), Aug. 15, 1914. I.—Preserving concrete linings on fresh canal banks. (14), Sept. 3, 1914.—Seros Power Development, Lerida, Spain; diversion dam and canals. J. C. Stevens. (14), Sept. 3, 1914. D. I.

COFFERDAMS.

Cellular sheet-pile coffer-dams; the Maine coffer-dam and its lessons. (14), July 23, 1914.—The coffer-dam for the 46th Street pier, North River, N. Y. City. (14), July 23, 1914.—Deep coffer-dam for 1050-ft. pier in New York. (15), July 18, 1914. I.—The great coffer-dam for the Hudson River piers. R. G. Skerrett. (27), Aug. 1, 1914. D. I.—Mississippi River coffer-dam fails. (15), July 11, 1914. D; (15), July 18, 1914. I.

CONCRETE.

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CRANES, HOISTS, ETC.

Hoisting wrecked locomotive from river bottom. (15), June 6, 1914. D.

DAMS.

Another masonry-placing record at Kensico Dam. (15), May 30, 1914.—Break in Hatchtown Dam. J. Jenson. (15), June 27, 1914. D. I.—Bridge and ferry building by Engineer Corps of Austrian Army. (14), Aug. 6, 1914. I.—Brunet Falls dam closures. A. R. Rhenisch. (15), May 2, 1914. D.—Concreting the Arrowrock dam. C. H. Paul. (15), Aug. 8, 1914. I.—Constructing hollow reinforced concrete dam in Porto Rico. L. V. Branch. (15), June 27, 1914 . D. I.—The design and construction of the Bassano Dam, part 1. H. B Muckleston. (14), Aug. 27, 1914. D. I.; part 2. (14), Sept. 3, 1914. D. I.—The Elephant Butte dam. (27), Aug. 1, 1914. I.—Europe's highest dam completed. (15), June 6, 1914. I.—Hatch Town dam breaks. (15), May 30, 1914.—Hebron earth dam washed out. C. B. Case. (15), May 30, 1914.—Hoe to plan the execution of a contract for a masonry dam. (39), Aug. 1, 1914.—Movable crests for dams. (15), June 20, 1914. D.—(3), Aug. 6, 1914. D.—The new Loch Raven dam at Baltimore, Md. E. B. Whitman. (14), Aug. 13, 1914. D. I.—Notes on maintenance of Wachusett Reservoir. J. A. Cushman. (14), Aug. 13, 1914.—Reports on break in Hatchtown earth dam. (15), July 11, 1914.—Rolling dams for Long Lake development. (15), Sept. 19, 1914. D.—Seros Power Development, Lerida, Spain, diversion dam and canals. J. C. Stevens. (14), Sept. 3, 1914. D. I.—State inspection of dams in Connecticut. (15), June 6, 1914. D.—A temporary sand-bag dam. (14), Aug. 6, 1914. I.—Test of emergency dam. (41), Aug. 5, 1914.—Washout of Lake George dam. J. E. Field. (15), July 11, 1914.—Woelfelsgrund Dam. (15), May 30, 1914. D.

DAMS, MOVABLE.

Winter operation of movable dams. (15), May 30, 1914. I.

DEMOLITIONS.

Demolition of masonry walls. G. B. Pears. (32), Sept., 1914. I.

DERRICKS.

A bridge repair derrick. (14), July 23, 1914. D.

DIKES.

Bronx terminal, N. Y. City. J. R. Marsh. (15), June 27, 1914. D. I.—Improving Tennessee River above Chattanooga, Tenn., by regulation or "Open channel method." N. W. Bowden. (30), Nov.-Dec., 1914.—How the Fall Creek dyke was built at Indianapolis. D. J. Hauer. (39), Sept. 1, 1914. D. I.

DOCKS. (See, also, Floating Docks.)

The Alexandria Dock extension at Newport. (11), July 10, 1914. D. I.; (11), July 24, Aug. 7, Aug. 14, 1914. D. I.—Building Pennsylvania Railroad coal dock at Sandusky, O. (39), July 15, 1914. I.—The new coaling dock at St. Thomas. G. T. Mason. (28), Aug. 15, 1914. D. I.—New docks at Bombay. (10), March 27, 1914. The new Joint dock at Hull. (10), June 19, 1914. D. I.; (11), June 26, July 3, 1914. D. I.—New works at Portsmouth dockyard. (11), April 10, April 17, May 1, 1914. D. I.—Reinforced concrete docks, foreign and American structures. Failures, costs and general considerations. H. S. Taft. (21), April, 1914.—Table of costs of reinforced concrete dock structures. (12), July 22, 1914.

DRAINAGE AREAS.

Yield of drainage areas. (15), Sept. 19, 1914.

DREDGES AND DREDGING.

Bucyrus dipper dredgers on the Panama Canal. (11), Sept. 4, 1914.—The hydraulic dredge "Niagara" and its work in the Saginaw River. (14), Aug. 27, 1914. I.—Performance of sea-going suction dredge "New Orleans." E. H. Schulz. (15), Sept. 19, 1914.

EMBANKMENTS.

A 40-ft. railway bank made by hydraulic fill. (14), Sept. 10, 1914. I.

ENGINEER TROOPS.

The tactics of divisional engineers. (30), Nov.-Dec., 1914.

ENGINEERING-CONTRACTS.

How to plan the extension of a contract for a masonry dam. (39), Aug. 1, 1914.—Special representations in specifications control. General cautionary clauses. W. B. King. (15), May 2, 1914.

EUROPEAN WAR.

The war and the British engineer. (10), Aug. 28, Sept. 4, 1914.—Warfare and the engineering press. (3), Sept. 3, 1914.

EXPLOSIVES.

A new explosive. (3), July 30, 1914.

FLOATING DOCKS.

New works at Portsmouth dockyard. (11), May 1, 1914. D.—Wharf and jetty for floating dock at Portsmouth dockyard. (11), April 24, 1914. D.

FLOATING SHEERS.

60-ton floating sheers for Valparaiso. (11), April 10, 1914. I.

FLOODS. (See, also, Levees; Missisipi River.)

Army board submits flood report. (15), May 2, 1914.—Board of eminent American engineers to sail shortly for China. (15), June 6, 1914.—Comparisons of systems of flood control. H. A. Peterson. (15), May 2, 16, 1914; The same. W. R. Smith, Jr. (15), July 18, 1914.—A defense of the Pittsburgh Flood Commission. (14), July 23, 1914.—Flood control as an investment. (15), July 4, 1914.—Flood prevention. J. C. Oakes. (3), July 30, 1914.—The Little River drainage improvements. (15), Aug. 22, 1914. D.—Paris inundation plans. F. P. Mann. (15), Aug. 15, 1914.—Pittsburgh Flood Commission answers Sir William Willcocks. (15), July 25, 1914.—Progress report on floods and flood prevention. (15), June 13, 1914.—Report of consulting engineer on Miami flood prevention plans. (15), Aug. 8, 1914. D.

GROINS.

The war against waves. (15), June 13, 1914.

GUN PLATFORM FOUNDATION.

Gun platform foundations. (15), June 13, 1914.

HARBORS. (See,also, Breakwaters; Docks.)

Harbour construction at Frankfort-on-Main. (11), Aug. 28, 1914. D.—Hartlepool harbour improvements. (10), July 24, 1914.—Municipal harbor construction in Minneapolis. (14), July 30, 1914. D.—The new coaling dock at St. Thomas. C. T. Mason. (28), Aug. 15, 1914. D. I.—Port of Burnie. (10), July 24, 1914.—The port of Calcutta. (11), July 17, 1914. D.—Toronto harbor improvements are most comprehensive on American continent. (15), Sept. 19, 1914. D.

HYDROGRAPHIC SURVEYING.

Hydrographic surveying with a four-man party. B. L. Rees. (14), Aug. 6, 1914. I.

INLAND NAVIGATION.

Intracoastal waterways. The Cape Cod Canal. A. St. Clair Smith. (46), May-June, 1914. D.—Note sur quelques ports maritimes de la Cote Atlantique et sur la navigation des Grands acs de l'Amerique du Nord. M. G. de Joly. (1), March-April, 1914. D. I.—Sweden's waterways. (11), July 24, 1914.

INSTRUMENTS.

Notes on the use of engineers' instruments. C. E. Clark. (14), April 30, 1914.

IRRIGATION.

Irrigation in India. R. H. Cunningham. (44), June, 1914. D.—Sudan irrigation plan. (12), May 20, 1914.

JETTIES.

The Alexandria Dock extension at Newport. (11), July 10, 1914. D. I.

LAND DRAINAGE.

A land-drainage problem in Missouri. C. H. Miller. (14), Sept. 17, 1914. D.

LEVEES.

Break in Volcano Lake levee. (15), July 4, 1914. D. I.—Building a levee. (39), Aug. 1, 1914. I.—A cable-drag scraper on Mississippi levee work. (14), Sept. 10, 1914. I.—Colorado River levee breaks; damage slight; fear more trouble from floods. (15), June 20, 1914.—How the ancients would have controlled the Mississippi. T. G. Dabney. (15), July 25, 1914.—The same. W. Willcocks, part 2. (15), July 4, 1914. —A land-drainage problem in Missouri. C. H. Miller. (14), Sept. 17, 1914. D.—Recent levee work to protect the Imperial Valley. W. L. Marshall. (15), Aug. 8, 1914. D. I.—The Savannah River levee, Augusta, Ga. N. Wingfield. (14), Aug. 6, 1914. D. I.

LIGHTHOUSES.

New lighthouse at Cape Point. H. C. Cooper. (10), Aug. 7, 1914. I.

LOCKS AND LOCK GATES.

The Alexandria Dock extension at Newport. (11), July 10, 24, 1914. D. I.—Drydocking in canal locks. C. W. Fisher. (27), April 18, 1914. I.—Floating lock-gate lifter. (15), Sept. 19, 1914. I.—Lake Superior to be regulated. (Water Chronicle), Sept., 1914. D. I.—The Lake Washington Canal locks. (27), April 25, 1914. I.—The new Joint Dock at Hull. (11), June 26, July 3, 1914. D. I.; (10), June 19, 1914. D. I.—New lock and canal at "The Soo." (14), April 23, 1914. D. I.—The Savannah River levee, Augusta, Ga. N. Wingfield. (14), Aug. 6, 1914. D. I.—300,000 horse-power hydro-electric plant on the Mississippi. (10), May 8, 1914. D. I.—Vertical-framed lock-gates, St. Paul-Minneapolis dam. (14), July 2, 1914. I.

LOGARITHMS.

Napier and the invention of logarithms. G. A. Gibson (28), July 11, 1914.

MATERIALS.

Annual meeting of the American Society for Testing Materials. (14), July 9, 1914. —Compression tests on woods. P. W. Smith. (10), April 10, 1914. D. I.—Relation between research and technical society activities. (15), July 11, 1914.—Relation be-

tween research and activities of the American Society for testing materials. A. N. Talbot. (12), July 22, 1914.—Useful facts about materials. (14), July 23, 1914.

MATTRESSES.

A dry-land mattress on the Mississippi. F. Y. Parker. (14), June 4, Aug. 13, 1914. D. I.—Mississippi River protection mat construction. (15), July 18, 1914. I.

MEXICO.

Roads between Vera Cruz and Mexico City. G. Borden. (15), May 23, 1914. D. I. —U. S. Army camp sanitation in Mexico. W. C. Gorgas. (15), May 16, 1914. D. I.

MILITARY BRIDGES.

Bridge and ferry building by Engineer Corps of Austrian Army. (14), Aug. 6, 1914. I.—The Universal improvised trestle. (32), Sept., 1914. D.—Use and development of the Ponton equipage of the U. S. Army, with special reference to the Civil War. M. J. McDonough and P. S. Bond. (30), Nov.-Dec., 1914.

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How the ancients would have controlled the Mississippi. T. G. Dabney. (15), July 25, 1914.—The same. W. Willcocks. (42), April, 1914; part 2 (15), July 4, 1914.—Mississippi River protection mat construction. (15), July 18, 1914. I.—Pittsburgh Flood Commission answers Sir W. Willcocks. (15), July 25, 1914.

PANAMA CANAL.

Bucyrus dipper-dredges on the Panama Canal. (11), Sept. 4, 1914.—Les conceptions techniques. Les consequences economiques. M. Geraud. (48), April 15, 1914. D. I. —The cost of building the Panama Canal. (14), Aug. 20, 1914.—The same, as estimated and as built; a triumph for the engineering profession. (14), May 28, 1914.—The first large ship through the Panama Canal. (14), Aug. 20, 1914. I.—Gatun hydro electric development for the Panama Canal. (28), July 11, 1914. D. I.—Gatun hydro-electric plant, Panama Canal. (14), July 2, 1914. D. I.—The same (11), July 3, 1914. I.—Geological problems and the Panama Canal. (10), April 17, 1914.—A German view of the strategic importance of the Panama Canal. F. Zadrow. (46), May-June, 1914.—Goethals for full tolls. G. W. Goethals. (15), May 2, 1914.—Goethe and the Panama Canal. C. Weiss. (65), July, 1914.—The guns of Panama. C. M. Maigne. (27), May 2, 1914. I.—Lock entrance caissons for the Panama Canal. (11), June 5, 1914.—The same. A. S. Zinn, etc. (18), Sept., 1914. D. I.—The Panama Canal and the West Indies. F E. Whitton. (31), June, 1914. D. Maps.—The Panama Canal as a military asset. Translated by H. H. Fletcher. (51), July-Aug., 1914.—Universal use of electricity on the Panama Canal. D. P. Gaillard. (18), Sept., 1914. D. I.—Volume and cost of construction work on the Panama Canal to Jan. 1, 1914. (12), May 20, 1914.—The water supply of the Panama Canal. (14), Aug. 6, 1914.

PIERS.

Comparative costs of different design for piers. (15), June 6, 1914. D.—Deep cofferdams for 1050-ft. pier in New York. (15), July 18, 1914. I.—The great cofferdam for the Hudson River piers. R. G. Skerrett. (27), Aug. 1, 1914. D. I.—Large reinforced-concrete pier at Halifax. (15), June 13, 1914. D. I.—San Francisco and Machina piers, Havana. (15), June 27, 1914. D. I.

PILE DRIVERS AND PILE DRIVING.

New type of driver for large concrete piles. (15), May 30, 1914. I.

PUBLIC WORKS.

Bitter fight over river and harbor appropriation bill. (15), July 4, 1914.—Cutting down the river and harbor appropriations. (14), Sept. 17, 1914.

RAINFALL.

Notes on the relation between rainfall and yield. D. H. Thomson. (11), Sept. 4, 1914. D.—Kansas City rain-runoff diagram. R. S. Beard. (15), Sept. 19, 1914. D.

RESERVOIRS.

Notes on maint nance of Wachusett Reservoir. J. A. Cushman. (14), Aug. 13, 1914.—Reservoir embankment failure; Turlock irrigation district, Cal. (14), July 9, 1914. D. I.

RIVER DISCHARGE AND VELOCITY.

Stream-flow studies. E. H. Sargent. (14), April 23, 1914. D.

RIVER GAGING.

Stream gaging by titration; comparative tests of new chemical and standard methods of gaging stream flow. Trans. by G. Bloauw (etc.). (12), Sept. 16, 1914. D.

ROADS.

Combined road-roller, tar-sprayer, and sweeper. (11), July 17, 1914. I.—Industrial railway used in concrete road construction in Wayne County, Mich. (12), Sept. 9, 1914. I.—Instruction in highway engineering. C. Richardson. (14), Sept. 17, 1914.

SEA WALLS.

Carnarvon sea wall. H. C. Ritchie. (Surveyor), July 31, 1914. D. I.—Constructing a submarine riprap embankment to retain sand fill. (12), July 22, 1914. D. Undercliff Drive extension at Bournemouth. (10), July 31, 1914. D. I.

SHIP CANALS.

The Baltic and Black Sea canal scheme. (11), Aug. 21, 1914.—Reconstruction of the Kiel Canal. (27), Sept. 19, 1914. I.—The Houston ship channel. C. Crotty. (14), July 23, 1914. D.

SHORE PROTECTION.

Beach erosion and shore protection, Atlantic City, N. J. M. Golder. (14), May 28, 1914. D. I.—Shore protection on steeply sloping foreshores. C. Marchand. (14), June 11, 1914.—The war against the waves. E. L Corthell. (15), April 11, 1914. D.

SURVEYING.

Modern methods of stadia surveying. J. A. Macdonald. (3), July 30, 1914. D.—600 transit shots in eight hours. (15), June 6, 1914. I.—Speed on topographic surveys. L. E. Bishop. (15), Sept. 19, 1914.—The stereoscopic method of surveying, and a first trial of its application to a railway survey in China. G. A. G. Mueller. (21), Aug., 1914. D. I.

SURVEYING—INSTRUMENTS.

The substitution of metal taps and wires for bars in base measurements. W. Bowie. (19), June, 1914.

TIMBER.

New grading rules for yellow-pine timber. (15), May 23, 1914.—Grading yellow-pine timber for structural purposes. A. T. North. (18), Sept., 1914. D. I.

WAR SHIPS.

The armament of the Spanish battle-ship "Espana" (11), July 31, 1914. D. I.

WATER TERMINALS.

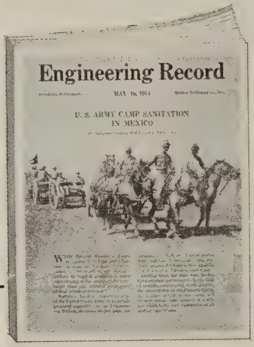
Barge Canal terminals. J. A. O'Connor. (15), Aug. 29, 1914. D. I.—Deep-water terminals at Halifax. T. W. J. Lynch. (3), July 30, 1914. D. I.—Municipal harbor construction in Minneapolis. (14), July 30, 1914 D.

WHARVES.

Part of wharf at Port Arthur, Ontario, collapses. C. E. Henderson. (15), July 25, 1914. I.—Suggested improvements on the construction of a timber wharf. D. J. Hauer. (39), Aug. 15, 1914. I.

WIRE DRAGS.

Recent improvements in the wire drag used by the U. S. Coast Survey; its possible use as a war machine. (14), Aug. 27, 1914. I.



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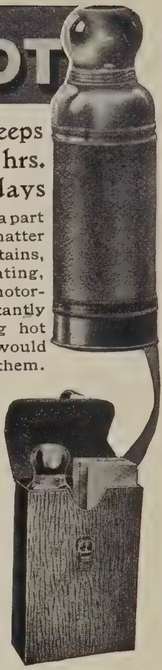

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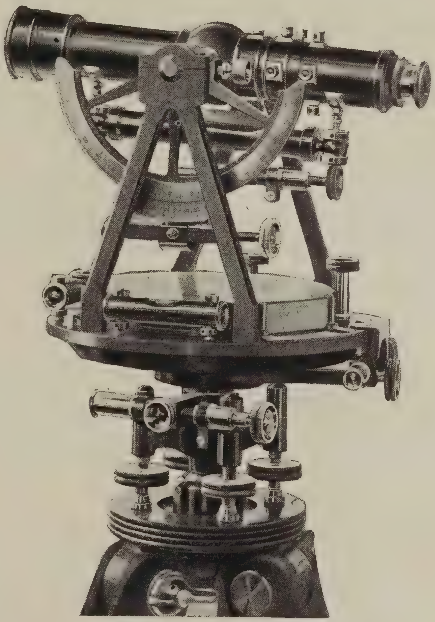

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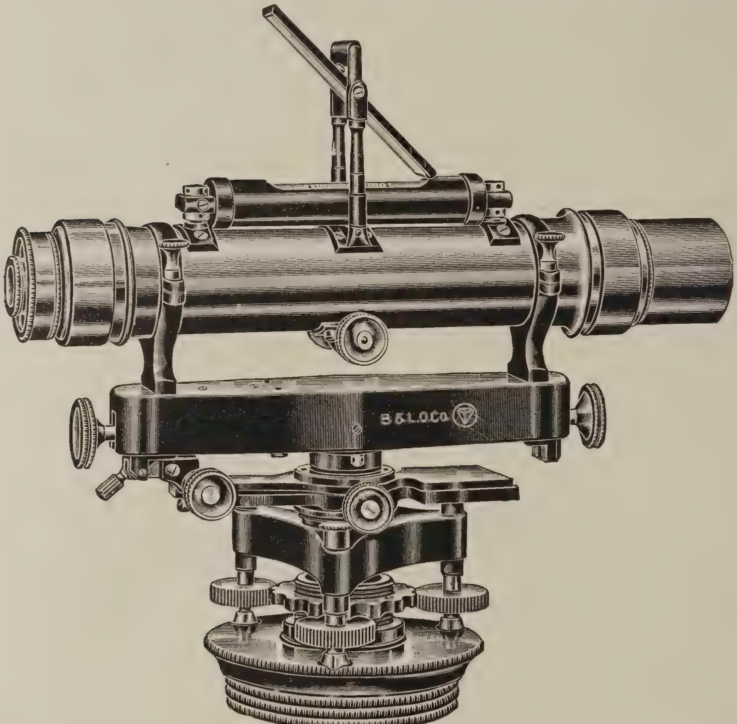

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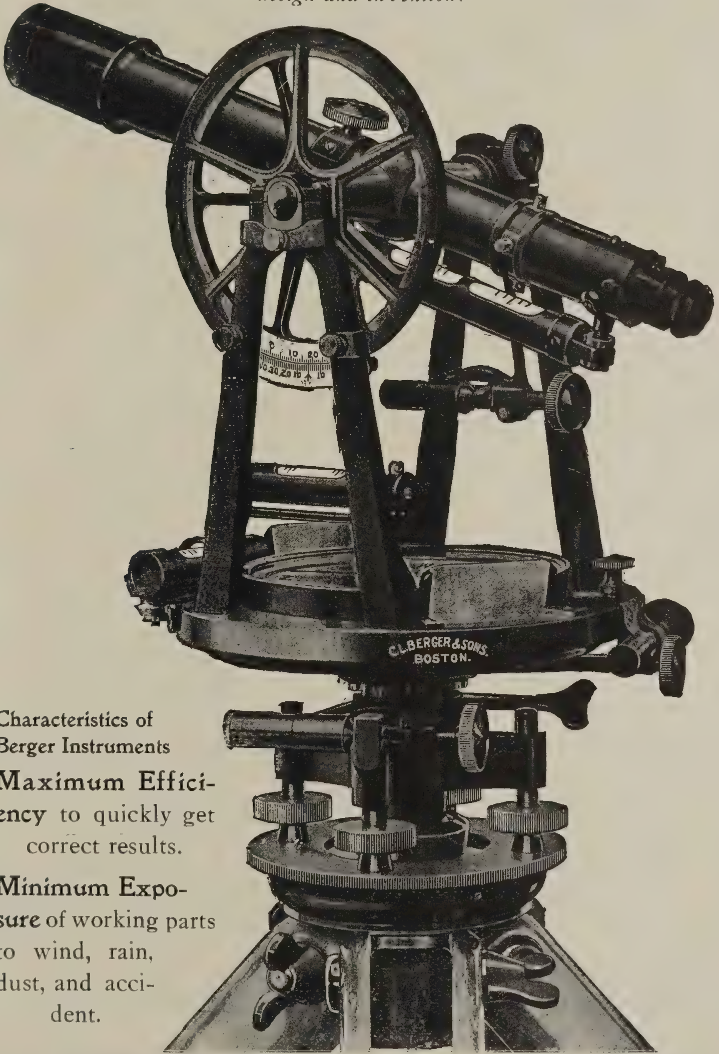

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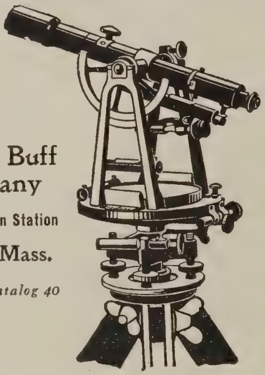

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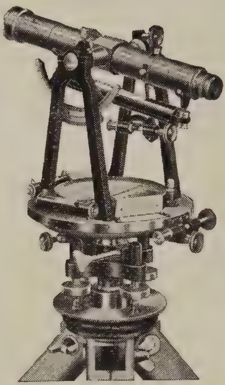

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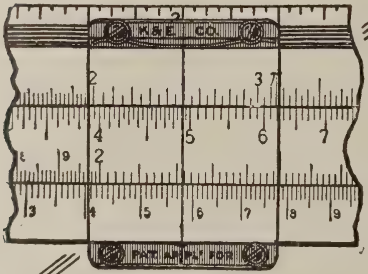

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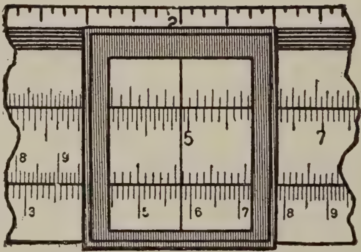

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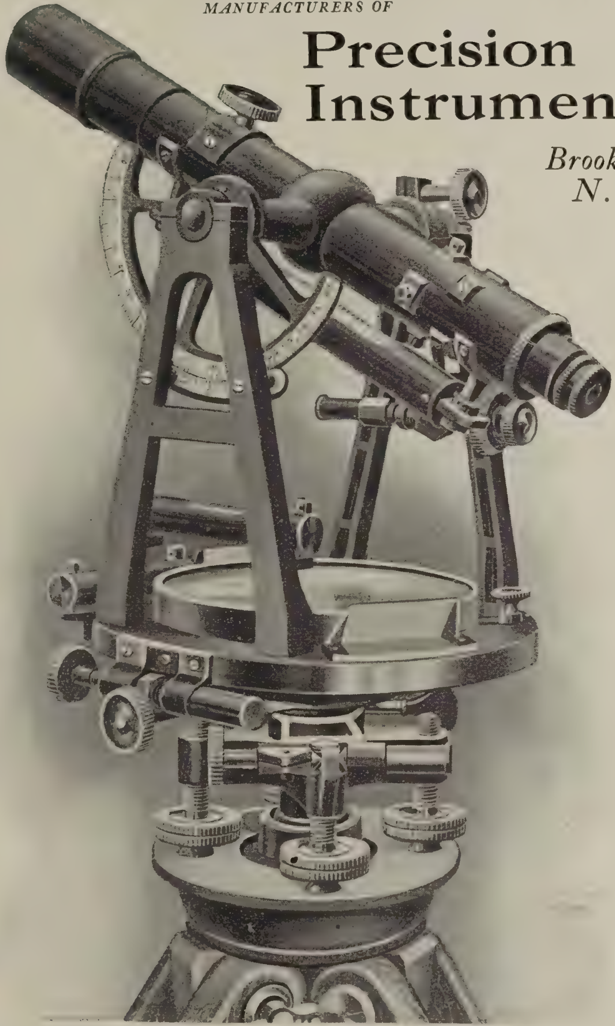

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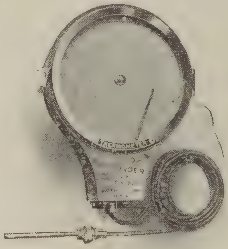

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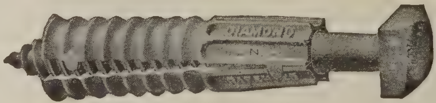

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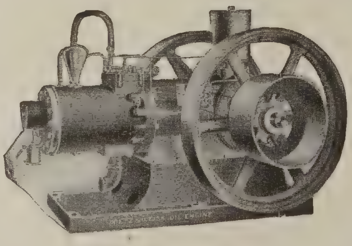

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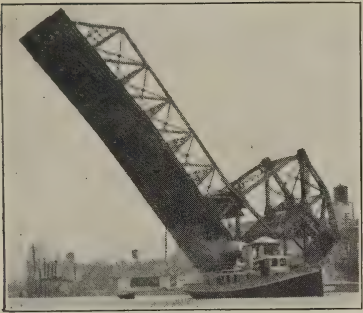

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DISAPPEARING SEARCHLIGHT TOWERS

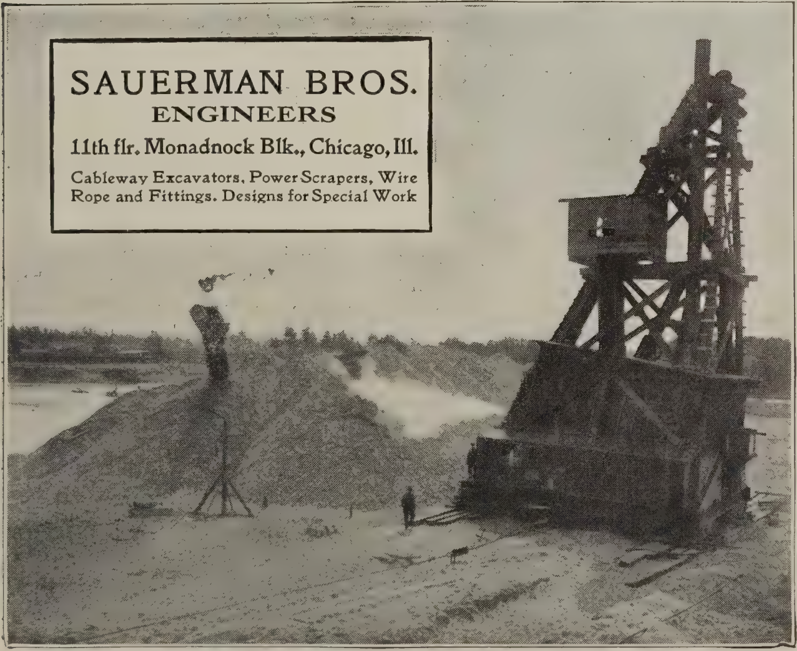
AND KINDRED STRUCTURES

120 Strauss Bridges are now in Service or under Construction; of these

6 are for the U. S. Government, no other Type of Bascule or Lift Bridge having been used by the Government; also

1 Disappearing Searchlight Tower based on the Strauss Bascule Principle, designed for Fort Hancock.

THE STRAUSS BASCULE BRIDGE CO., Engineers, 104 SOUTH MICHIGAN AVE., CHICAGO.



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"In all things, but proverbially so in mechanics, the supreme excellence is simplicity."—James Watt.

Simplicity in design, economy in construction, operation, and maintenance, and efficiency in service, the essential requirements of modern movable bridges, are all embodied in the highest degree in **Scherzer Rolling Lift Bridges.** The moving leaf is in one piece, with its counterweight firmly fixed to and rigidly bracing the trusses. There are no complicated links, pins, and flexible connections requiring constant attention and large expense to maintain. The large, simply constructed rollers supporting the moving span during its operation roll on smooth and level tracks without friction. Small power is required for operation and it is simply and directly applied. Simplicity is the keynote in the design of the Scherzer type of bridge. Economy and efficiency in service must necessarily follow. The most important Governments, Railroads, and Municipalities in the United States, England, Ireland, Holland, Russia, France, Egypt, India, Canada, Argentine, Mexico, etc., are using the Scherzer type of bridge, **more than 200 now being in service and under construction.** One-half of these are additional orders from satisfied patrons—further evidence of the superiority of the **Scherzer Rolling Lift Bridge** and demonstrating that the principle upon which it is based is fundamentally right.

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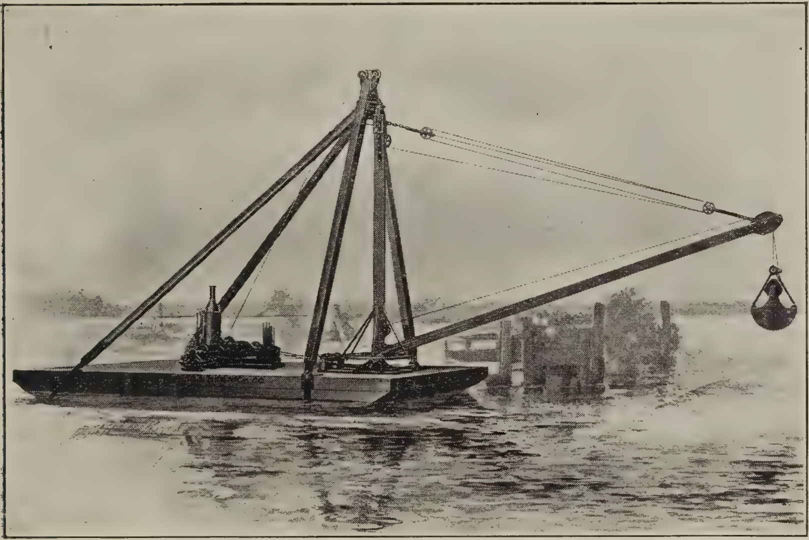

The mast is set forward of the "A" frame, permitting the boom to swing a full half circle.

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Derrick irons are heavier than usual and better finished.

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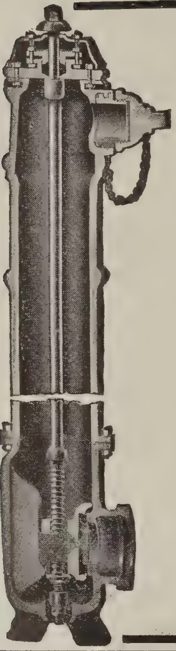

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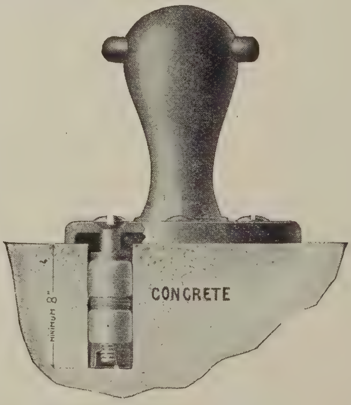

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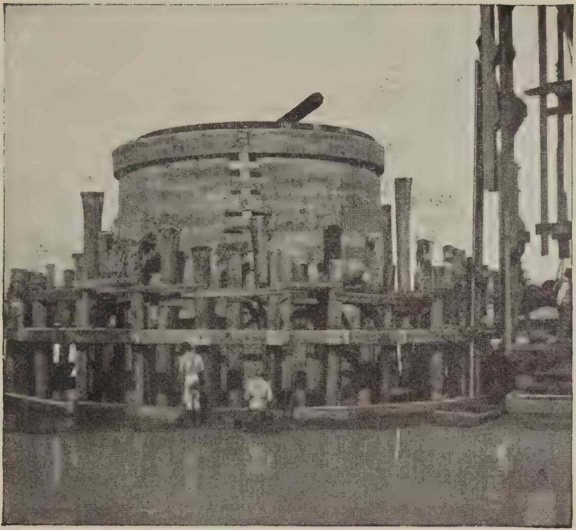

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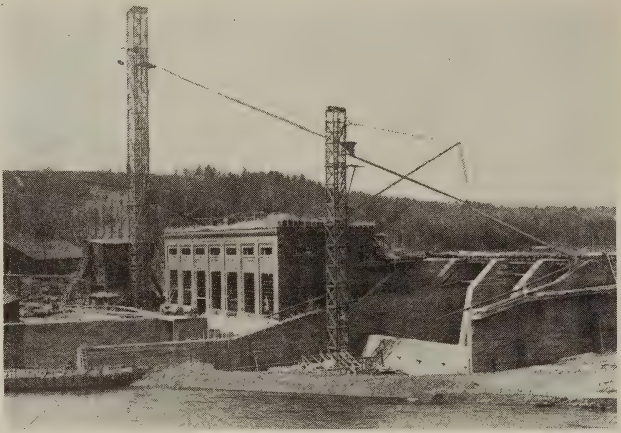

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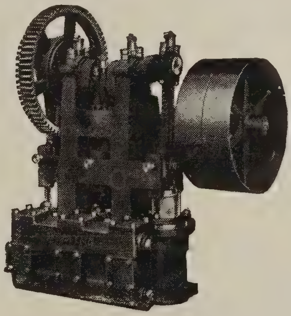

Fig. 50. Deming Belt Driven Triplex Power Pump

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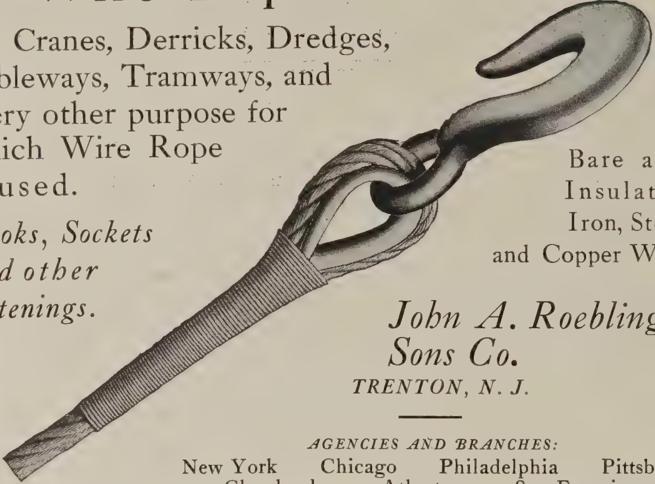

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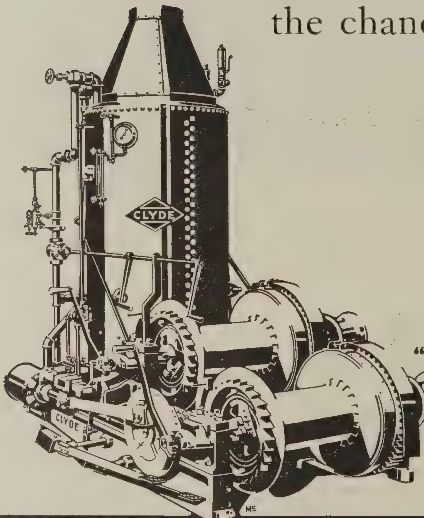

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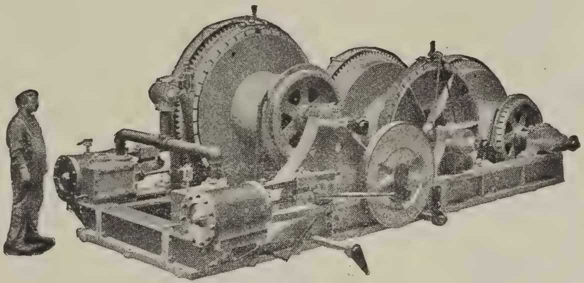

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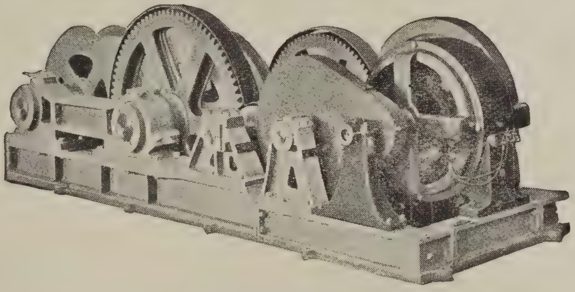

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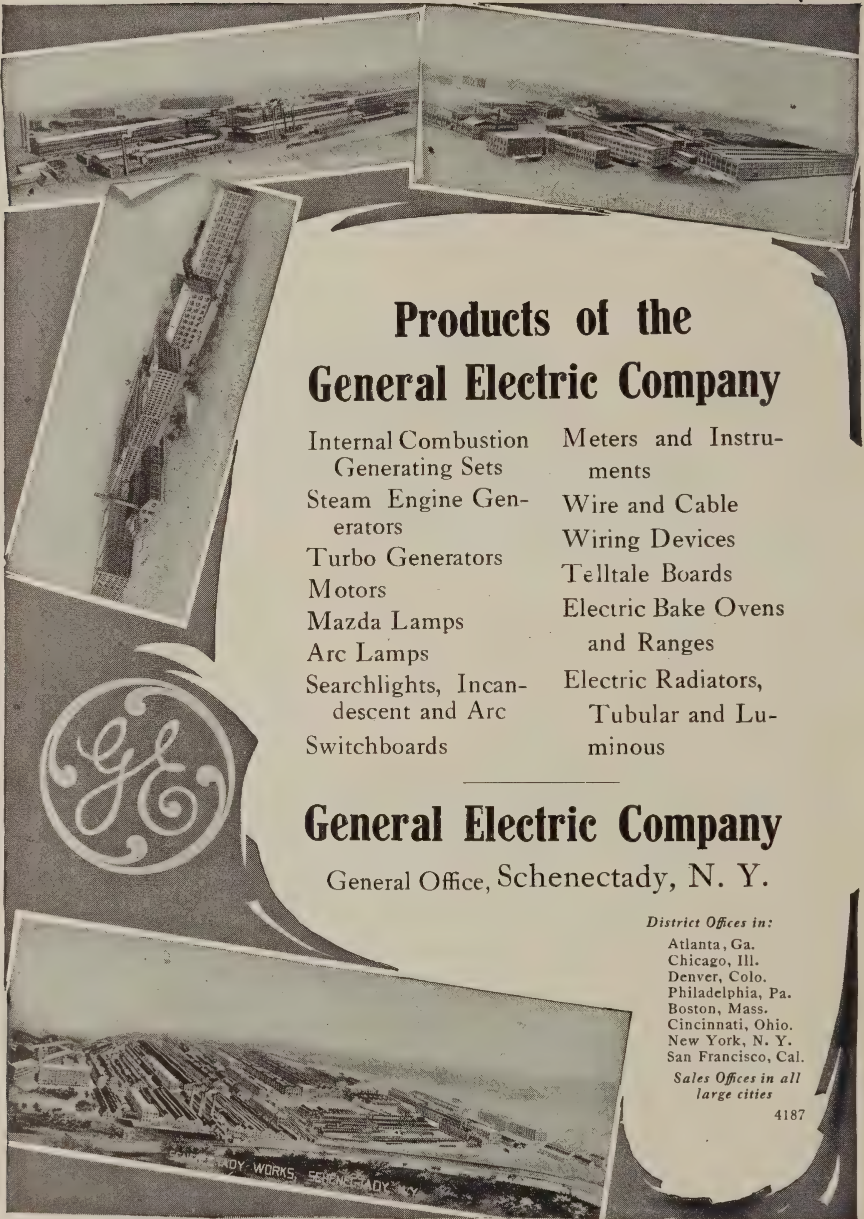

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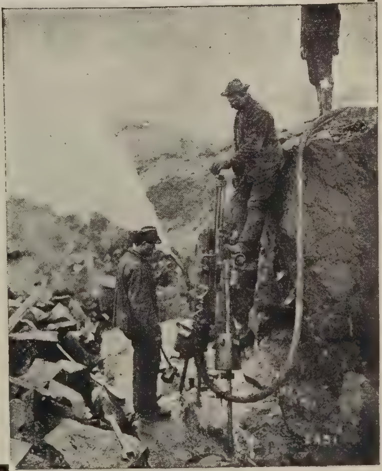

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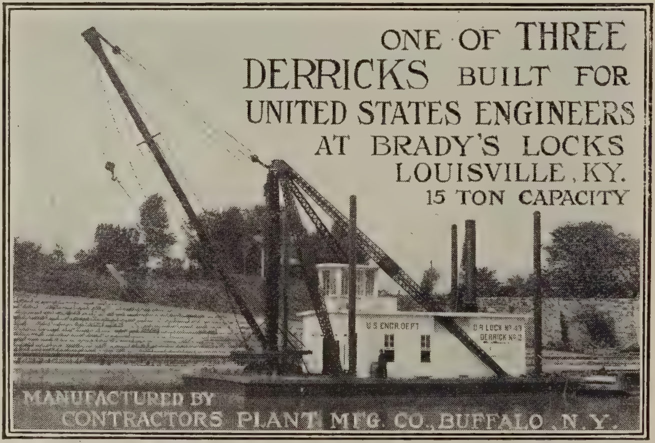
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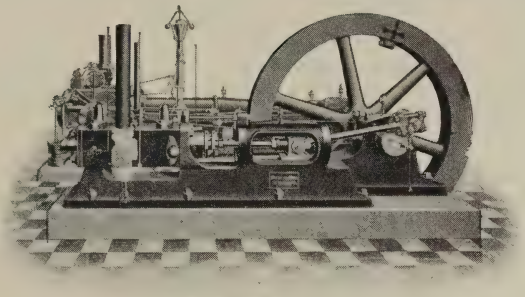

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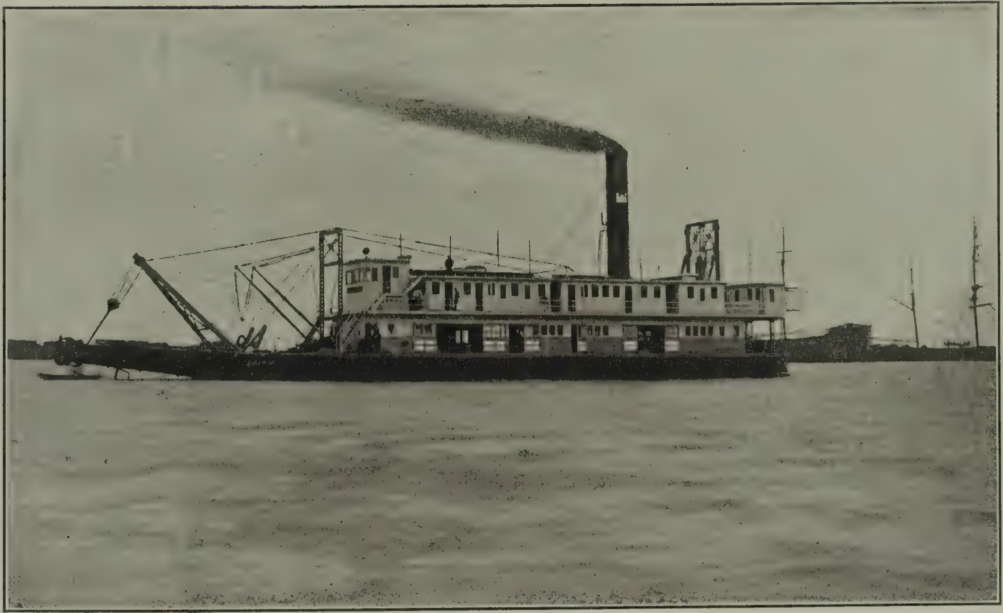

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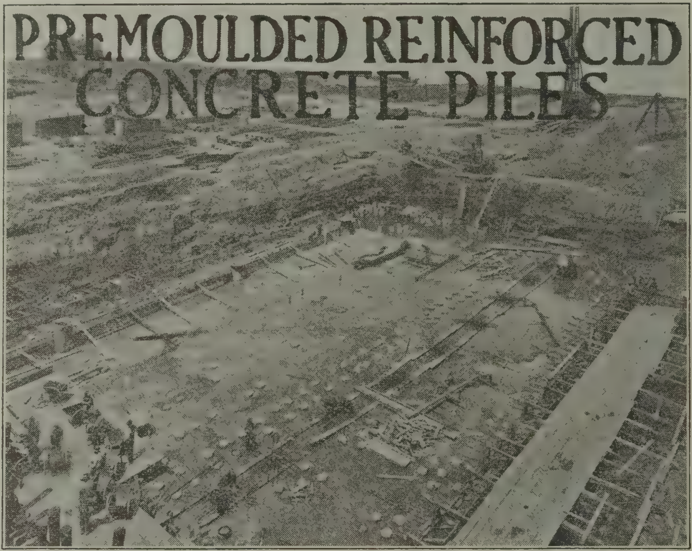

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